JULY 1961

Journal

VOL. 53 • NO. 7

AMERICAN WATER WORKS ASSOCIATION

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HARDNESS AND DETERGENT USE
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Lambie

GROUND WATER REPLENISHMENT
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ACCOUNTING FOR WATER
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CONCRETE PIPE INSTALLATION
Committee Report

DISTRIBUTION MANUAL
AWWA M8

STANDARD FOR COLD-WATER METERS
AWWA C700

On with John as Caesar gives up the gavel to AWWA's new President; Detroit, June 8

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Journal

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July 1961

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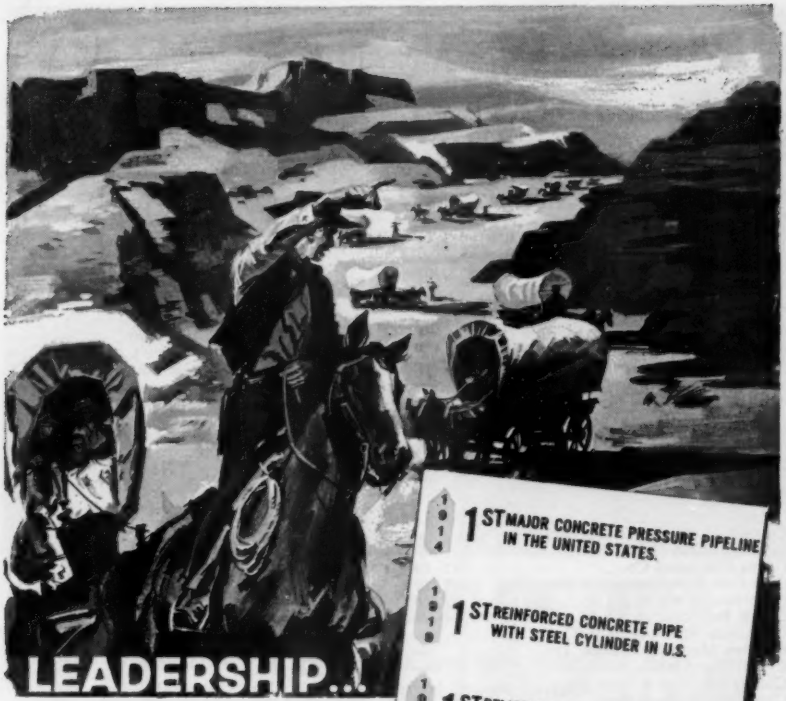

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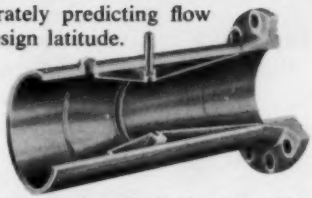

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Coming Meetings

AWWA SECTIONS

Fall 1961

Sep. 11–13—Kentucky-Tennessee Section, at Brown Hotel, Louisville, Ky. Secretary, Harold F. Mount, Gen. Mgr., Preston Street Road Water Dist. No. 1, 5400 Preston Hwy., Louisville, Ky.

Sep. 13–14—New York Section, at Saranac Inn, Saranac Lake. Secretary, Kimball Blanchard, Neptune Meter Co., 2222 Jackson Ave., Long Island City 1.

Sep. 13–15—North Central Section, at Pick-Nicollet Hotel, Minneapolis, Minn. Secretary, Carl A. Flack, Registrar, Water Dept., 216 City Hall, St. Paul 2, Minn.

Sep. 20–22—South Dakota Section, at Sheraton-Johnson Hotel, Rapid City. Secretary, J. Darrel Bakken, Div. of San. Eng., State Dept. of Health, Pierre.

Sep. 27–29—Wisconsin Section, at Hotel Schroeder, Milwaukee. Secretary, Harry Breimeister, Bureau of Engineers, Room 607 Municipal Bldg., 841 N. Broadway, Milwaukee.

Sep. 28—Connecticut Section. Secretary, D. W. Loiselle, Supt. of Supply, Bridgeport Hydraulic Co., 835 Main St., Bridgeport.

Oct. 1–3—Missouri Section, at Kentwood Arms Hotel, Springfield. Secretary, Warren A. Kramer, Chief, Water Supply, Div. of Health, State Office Bldg., Jefferson City.

Oct. 2–3—Maritime Branch, Canadian Section, at Brunswick Hotel, Moncton, N.B. Secretary, J. D. Kline, Gen. Mgr., Public Service Com., Halifax, N.S.

Oct. 2–4—Rocky Mountain Section, at La Katchina Hotel, Taos, N.M. Secretary, H. F. Kepner, Vice-Pres., Dana Kepner Co., 550 Alcott, Denver, Colo.

Oct. 4–6—Virginia Section, at Hotel Roanoke, Roanoke. Secretary, Edward H. Ruehl, R. Stuart Royer & Assocs., 15 W. Cary St., Richmond 20.

Oct. 5–6—Intermountain Section, at Twin Falls, Idaho. Secretary, M. W. Snell, Supt., Power & Water, Soda Springs, Idaho.

Oct. 8–11—Alabama-Mississippi Section, at Buena Vista Hotel, Biloxi, Miss. Secretary, Ernest Bryan, Southern Sales Mgr., McWane Cast Iron Pipe Co., Box 2601, Birmingham, Ala.

Oct. 15–18—Southwest Section, at Granada Hotel, San Antonio, Tex. Secretary, L. A. Jackson, Mgr.-Engr., Municipal Water Works, Robinson Memorial Auditorium, Little Rock, Ark.

(Continued on page 8)

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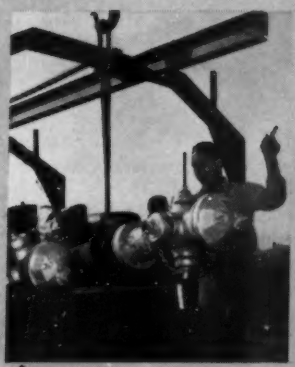
by the carload to meet San Jose Water Works' growing requirements

Glimpse of new subdivision of San Jose, California. City has grown from 95,280 to 202,571 in past ten years.



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Two IOWA gate valves and a new hydrant being installed. Hundreds of these Iowa products are important components of San Jose's modern system.

Carloads of IOWA gate valves and hydrants were purchased by the San Jose Water Works (an investor-owned, private company established in 1866) for installation in their rapidly expanding system which serves seven cities and unincorporated areas in Santa Clara County, California.

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Oskaloosa, Iowa
Subsidiary of James B. Clow & Sons, Inc.

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Coming Meetings

(Continued from page 6)

Oct. 18–20—Iowa Section, at Roosevelt Hotel, Cedar Rapids. Secretary, Wilbur E. Bjork, Service Supt., Des Moines Water Works, 1003 Locust St., Des Moines.

Oct. 25–27—California Section, at Hotel Senator, Sacramento. Secretary, Frank F. Watters, Hydr. Engr., State Public Utilities Com., State Bldg., Civic Center, San Francisco.

Oct. 25–27—Ohio Section, at Commodore Perry Hotel, Toledo. Secretary, J. H. Bass, Henry P. Thompson Co., 4866 Cooper Rd., Cincinnati.

Oct. 25–28—New Jersey Section, at Dennis Hotel, Atlantic City. Secretary, A. F. Pleibel, District Sales Mgr., R. D. Wood Co., 683 Prospect St., Maplewood.

Oct. 29–Nov. 1—Florida Section, at Cherry Plaza Hotel, Orlando. Secretary, John B. Miller, Director, Div. of Water Supply, Bureau of San. Eng., State Board of Health, Box 210, Jacksonville 1.

Nov. 1–3—Chesapeake Section, at Emerson Hotel, Baltimore, Md. Secretary, Carl J. Lauter, 6955—33rd St. N.W., Washington, D.C.

Nov. 13–15—North Carolina Section at George Vanderbilt Hotel, Asheville. Secretary, T. Z. Osborne, Asst. Director of Public Works, Greensboro.

OTHER ORGANIZATIONS

Sep. 17–21—NEWWA, Poland Springs, Me.

Oct. 4–6—North Dakota Water & Sewage Conference, Gladstone Hotel, Jamestown, N.D.

Oct. 8–12—WPCF, Milwaukee, Wis.

Nov. 13–17—APHA, Cobo Hall, Detroit, Mich.

Nov. 27–Dec. 1.—28th Exposition of Chemical Industries, Coliseum, New York, N.Y.

SHORT COURSES

Jul. 23–Aug. 4—10th Annual Utility Management Workshop, sponsored by Columbia Univ., at Arden House, Harriman, N.Y. Write: M. F. Garvey, 409 Engineering Bldg., Columbia Univ., New York 27, N.Y.

Jul. 24–28—Training course on "Recent Developments in Water Bacteriology," R. A. Taft Sanitary Engineering Center, Cincinnati, Ohio. Write: Chief, Training Program, 4676 Columbia Pkwy.. Cincinnati 26, Ohio (or to USPHS regional director).

Oct. 23–27—10th Annual Water Works Management Short Course, sponsored by the Illinois and Indiana sections, AWWA, at Allerton House, Monticello, Ill. Write: Short Course Supervisor, 116B Illini Hall, Champaign, Ill.

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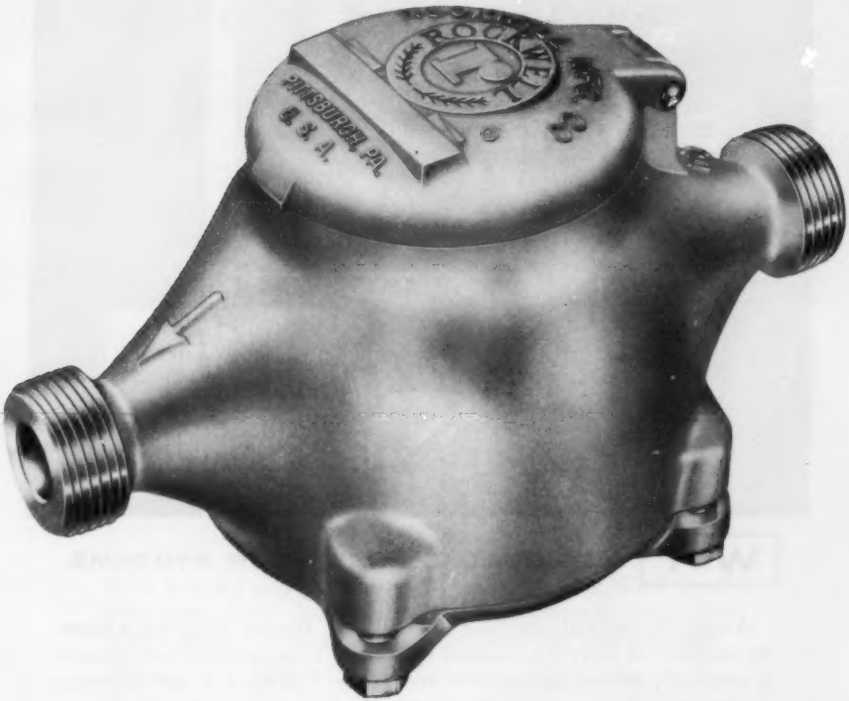
(there are many in your area)



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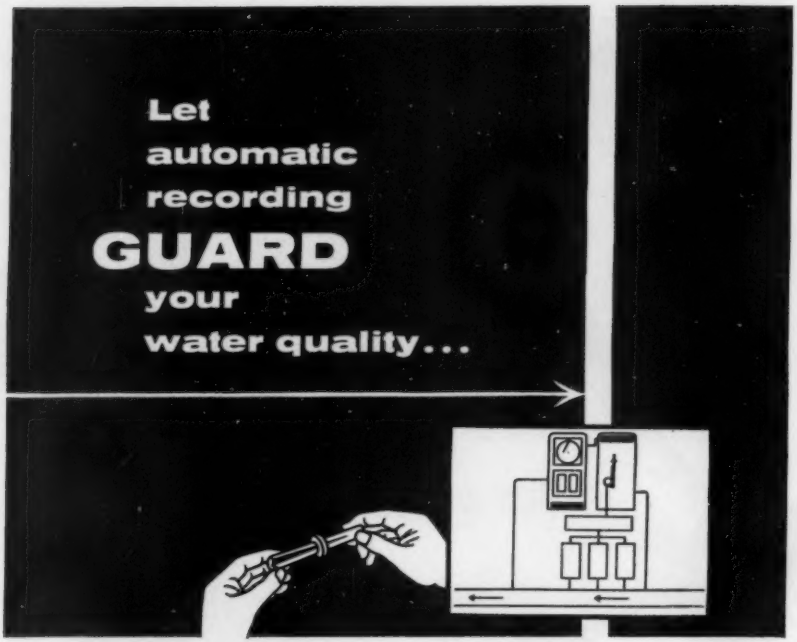

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Now you can stop paying freight on water. The W&T Paste-type Lime Slaker lets you buy unslaked lime—lets you slake it in your own plant completely, continuously, conveniently.

Wallace & Tiernan's Lime Slaker works with a constant paste slurry, controlled by a torque-actuated water valve. Slaking is complete in 5 minutes, water to lime ratio only 2:1. And the W&T Slaker needs no pre-heating, no insulation. You get a smaller, more compact slaker. The 1000 lb./hr. model occupies less than 6 ft. x 2 ft. of floor space; the 8000 lb./hr. model, less than 46 sq. ft.

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With the W&T Lime Slaker, you slake lime in your own plant . . . save on freight.

Write for information, Dept. M-58.05.

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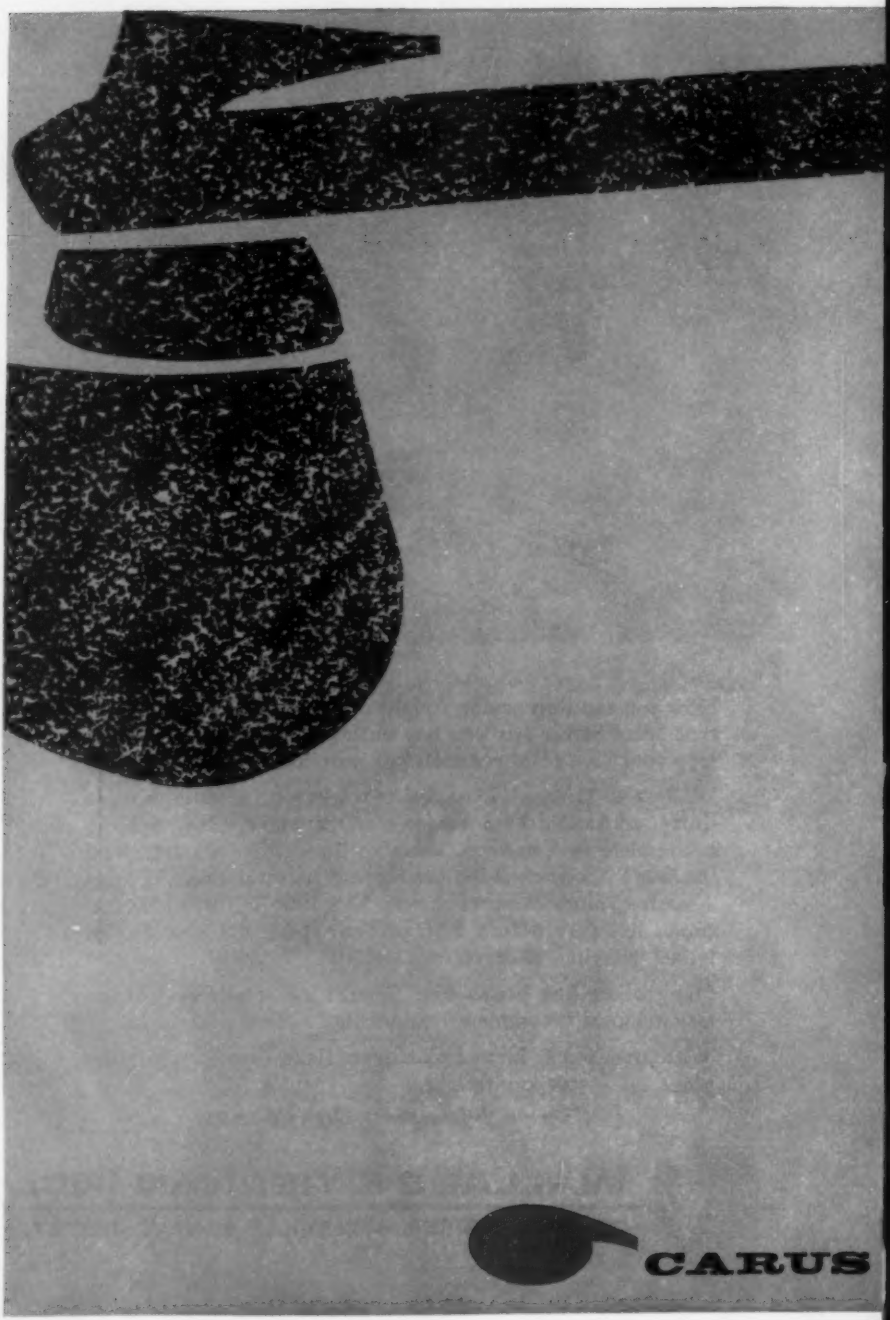
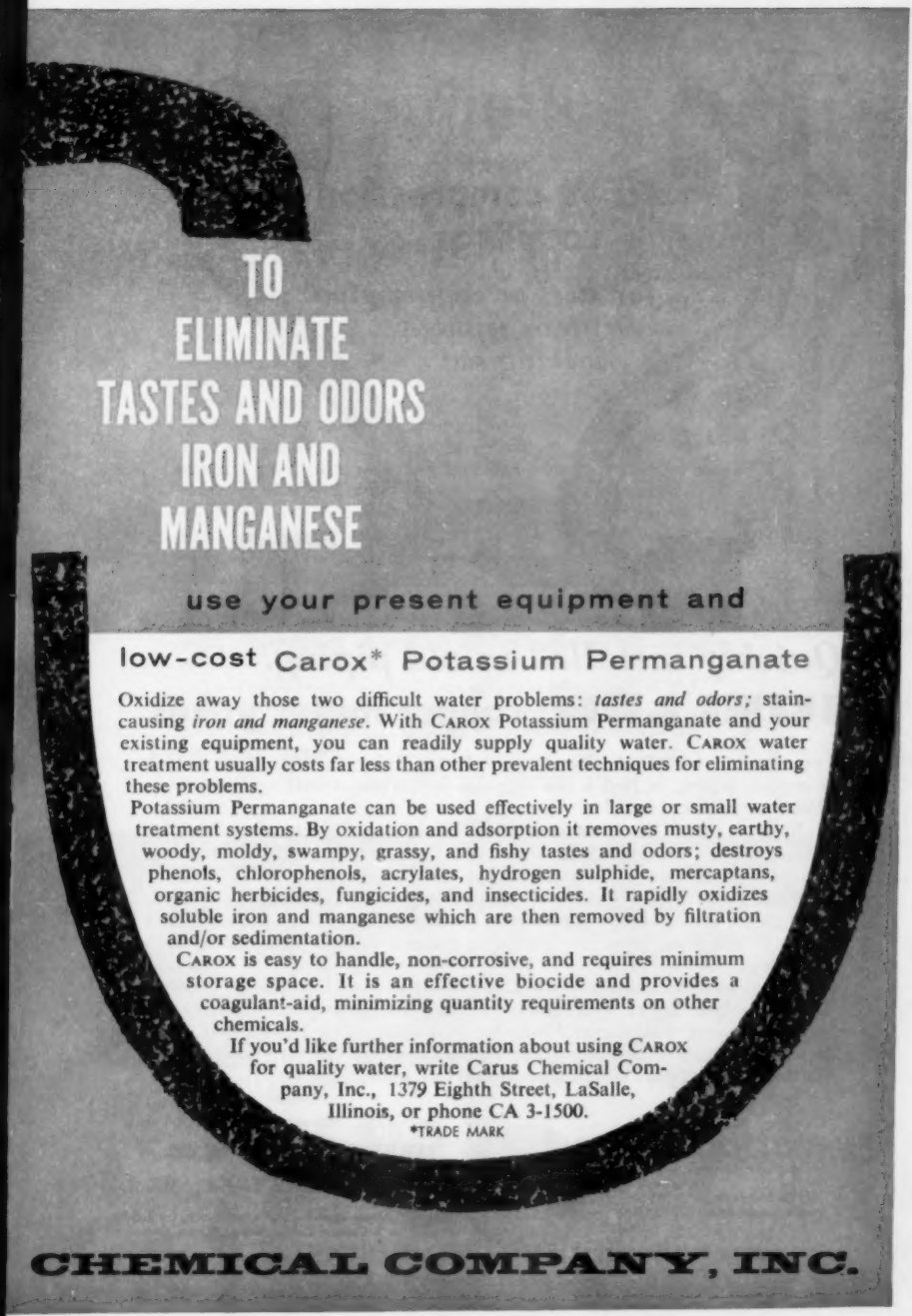

CARUS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use your present equipment and
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Oxidize away those two difficult water problems: tastes and odors; stain-causing iron and manganese. With CAROX Potassium Permanganate and your existing equipment, you can readily supply quality water. CAROX water treatment usually costs far less than other prevalent techniques for eliminating these problems.
Potassium Permanganate can be used effectively in large or small water treatment systems. By oxidation and adsorption it removes musty, earthy, woody, moldy, swampy, grassy, and fishy tastes and odors; destroys phenols, chlorophenols, acrylates, hydrogen sulphide, mercaptans, organic herbicides, fungicides, and insecticides. It rapidly oxidizes soluble iron and manganese which are then removed by filtration and/or sedimentation.
CAROX is easy to handle, non-corrosive, and requires minimum storage space. It is an effective biocide and provides a coagulant-aid, minimizing quantity requirements on other chemicals.
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*TRADE MARK
CHEMICAL COMPANY, INC.

Quickly installed in old piping!

MUELLER® copper meter yokes

You can now install Mueller Copper Meter Yokes in any existing steel or copper piping in just a few minutes and without cutting threads or sweating joints.

Simply cut a short section from the pipe, slip the new Mueller Compression Couplings over the ends of the pipe, position yoke and assemble couplings to it and tighten the compression nuts.

That's all there is to it with Mueller's new Compression Couplings. Permanent, water-tight joints are quickly made even on rough and badly pitted pipe. Possible trouble is avoided because the piping does not have to be moved.

These new, time-saving couplings are now available for all Mueller Copper Meter Yokes with Multi-Purpose Ends. Regular compression nut or locking nut designs can be furnished. The locking nut type positively prevents any movement of the yoke on the pipe and insures continuous electrical bonding of the service piping.

Copper Meter Yokes are just a portion of Mueller's complete line of quality-matched meter setting equipment. Write for complete information and specifications.

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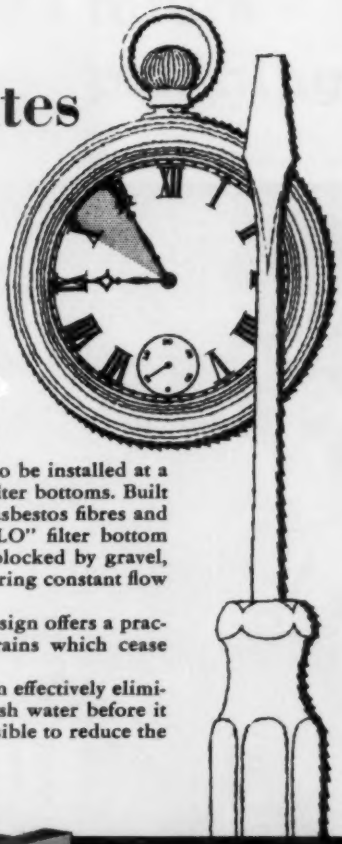
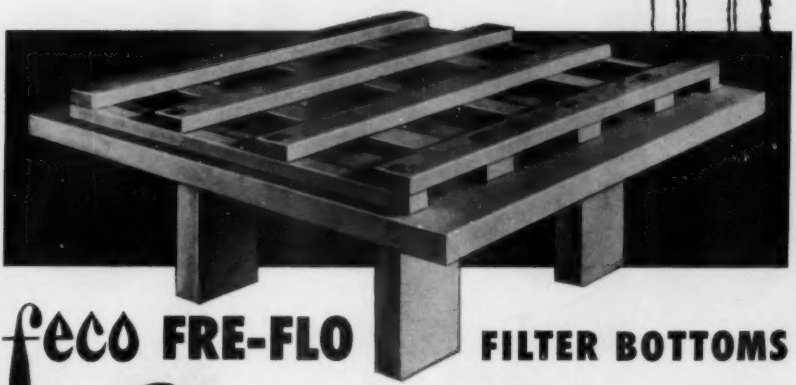
five minutes and a screwdriver



That's all it takes to complete the field assembly of a 24" square unit. This practical design of filter bottom offers superior performance and is the only underdrain system that does not have to be secured to the bottom of the filter. This feature makes it possible to be installed at a fraction of the cost of conventional filter bottoms. Built of strong, non-corrosive materials—asbestos fibres and Portland cement—the FECO "FRE-FLO" filter bottom is designed so that ports cannot be blocked by gravel, closed by expansion or enlarged, assuring constant flow and uniform backwash.

The flexibility of the "FRE-FLO" design offers a practical replacement of archaic underdrains which cease to perform adequately.

This false bottom type of underdrain effectively eliminates the velocity head of the backwash water before it enters the gravel layer, making it possible to reduce the amount of gravel.



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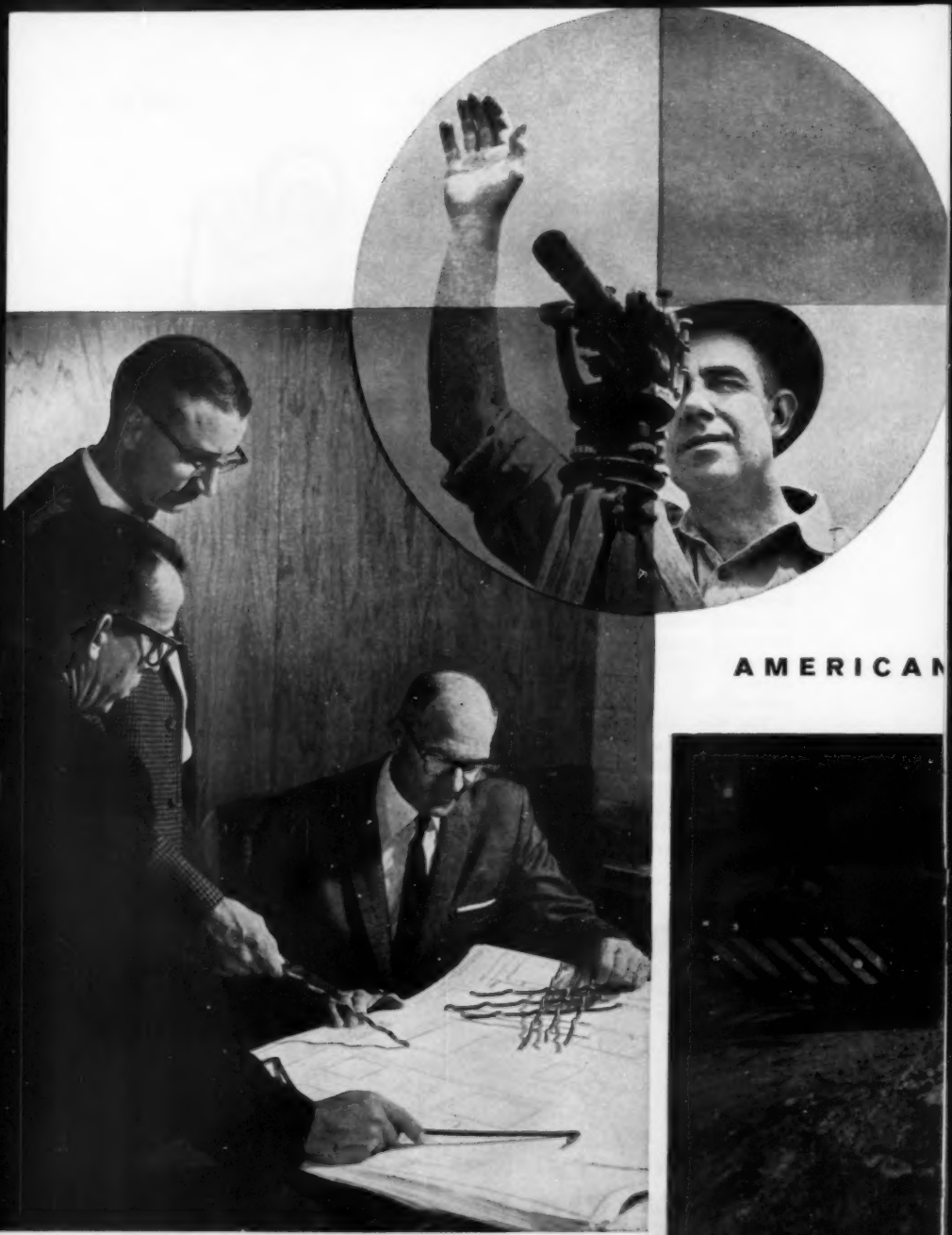

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Why are so many communities turning to concrete pressure pipe for their main water lifeline of the future? Farsighted waterworks authorities recognize that the present critical demands, brought about by our recent population and industrial explosion, may easily be doubled within the next 25 years.

They also recognize that, with concrete pressure pipe, plans for the future are laid on a solid foundation of an exceptional life span, minimum maintenance requirements and virtually no replacement costs. But most of all, their planning can be accurate, because concrete pressure pipe's initial high carrying capacity will remain unimpaired in years to come when demands on the line will be highest.

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Concrete PRESSURE Pipe

CONCRETE PRESSURE PIPE ASSOCIATION

228 North LaSalle Street • Chicago 1, Illinois

"here's what out of sight out of mind" does to a water main

"Out of sight—out of mind" can be a mighty expensive philosophy in any water distribution system. The above unretouched photograph proves this point. It shows a badly tuberculated *eight inch* main whose *inside diameter was reduced to an average of almost 4.5 inches.* Resultant higher pumping costs with reduced pressure and carrying capacity make it costly to tolerate such conditions. That is why the savings effected in reduced pumping costs frequently pay for the *low cost* of National water main cleaning.

Since there's never a charge or obligation to inspect your mains, *call National now!*

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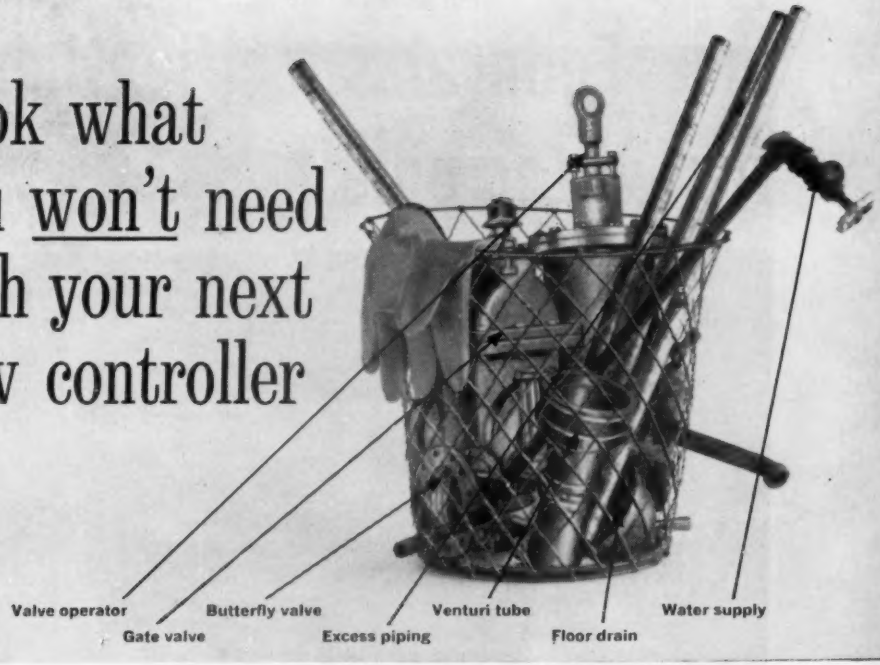
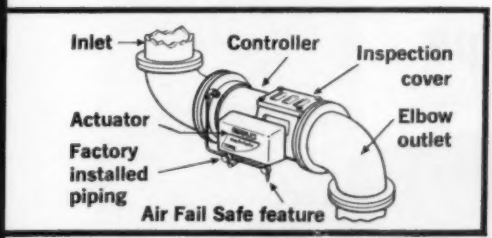
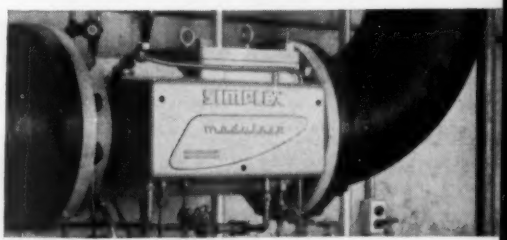
Look what you won't need with your next flow controller



NOW THERE'S A MODERN, surprisingly simple way to control flow in your filter effluent piping. The Modulair "P" rate of flow controller, fully pneumatic, installs almost as easily as a piece of pipe, gives you accuracy with less "hardware" and attention than other types of controllers.





SIMPLE! Preassembled unit saves you money on initial cost and installation cost. Simplicity of design reduces maintenance almost to zero. All working parts are enclosed. No hydraulic valves or valve operator. No water supply needed. No drive gears or linkage. No complicated piping. No pilot valve. No floor drain.

COMPACT! Shortest laying length of any flow controller. No appendages. Shown here: one of three Modulair controllers at modern filter plant in Fairmont, Minnesota. Note the trim, clean installation, with no "spaghetti" of hydraulic piping, no appendages. Unit is simply "a box on a pipe."

USEFUL, FREE BULLETIN. The space saving, low cost and operating economies of the Modulair "P" are fully detailed on the pages of our Bulletin 951. Complete specifications included. Write for a copy—with no obligation on your part.

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- complete Federal specification INT. SSP-00385
- Design Tables covering water pressure classes 100 to 400
- Friction Loss Table for nominal pipe diameters (waterways) from 4 to 48 inches and flows from 10 to 100,000 GPM
- a special section on Southern Pipe's exclusive PresSeal Joint with a Deflection Angle table for standard and deep bell PresSeal Joints and an Allowable Radii chart of curvature for various pipe lengths.

Get your water pipe answers from a Southern Pipe Sales Engineer....

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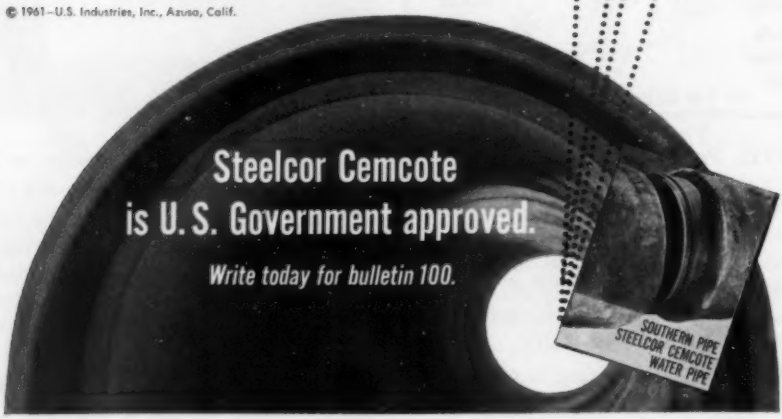
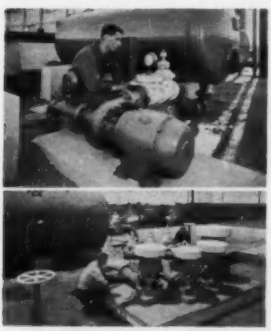


"These Peerless pumps deliver practically all of the 18 million gallons of water we distribute daily."

Says Thomas J. Clemmer, Operations Manager, Dominguez Water Corporation, Long Beach, Calif.



"During the past 14 years many of our Peerless pumps have been changed but only to increase our capacity."

"Many of our Peerless pumps have seen 25 or more years of continuous service and downtime for repairs is practically non-existent."

Throughout their system, Dominquez makes virtually constant use of 37 individual Peerless pumps ranging from tiny 2 hp Fluidyne models to giant 250 hp deep well turbine pumps to insure a constant flow of water to their 18,000 customers.

Standardize on Peerless pumps for all your water supply and pumping needs. Like the Dominquez Water Corporation, you'll find Peerless pumps last longer, cost less to maintain and do the job better. For full details on Peerless pumps for your application, write us or contact your Peerless representative.

PEERLESS PUMP

HYDRODYNAMICS DIVISION

FOOD MACHINERY AND CHEMICAL CORPORATION

301 WEST AVENUE 26, LOS ANGELES 31, CALIFORNIA

PIPE

Consulting engineers prefer cast iron pipe! Of 430 consulting engineers surveyed recently, two-thirds stated they would recommend cast iron pipe over any other.

DO YOU KNOW how many feet of pipe it takes to install a watering system in an 18-hole golf course? Hickory Hills Country Club — prominent tournament course in Springfield, Missouri — will use 22,000 feet. That's approximately 4,000 feet more than the playing distance of this course! A large portion of this piping is 3", 4" and 6" AMERICAN Fastite pipe.

DO YOU KNOW that pipe must meet four definite tapping requirements? It must . . . (1) Be strong enough to withstand tapping operation. (2) Be of an easily-tapped material that assures uniform threads. (3) Be strong enough to withstand service conditions after tapping. (4) Have threads that insure leak-proof connections after exposure to service stresses. Cast iron pipe meets all four requirements!

FACTS

DO YOU KNOW that a trainload of 11,000 feet of 36" AMERICAN cast iron pipe recently left Birmingham and arrived in Utica, New York . . . with only one pipe damaged? Such reports are not unusual and prove that cast iron pipe has the strength to withstand shocks and strains in transit . . . and also indicate the care AMERICAN exercises in banding and bracing pipe for shipment.

DO YOU KNOW that for river crossings and other difficult underwater installations, your best buy for permanence is AMERICAN Molox Ball Joint pipe? Here's why . . . (1) Pipe socket cast integrally with the pipe. (2) Heavy alloy steel follower gland for added strength. (3) High strength, corrosion resistant AMERICAN STAINLESS STEEL tee head bolts. It remains bottle-tight at any deflection; and changes in line and grade up to 15° can be made.

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BIRMINGHAM ALABAMA

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A full-fledged line-operated pH Meter of remarkable accuracy and stability at the low price of

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- FAST AND DEPENDABLE IN SERVICE

Write for Bulletin #225, also for literature on other Line-Operated and Battery-Operated Photovolt pH Meters

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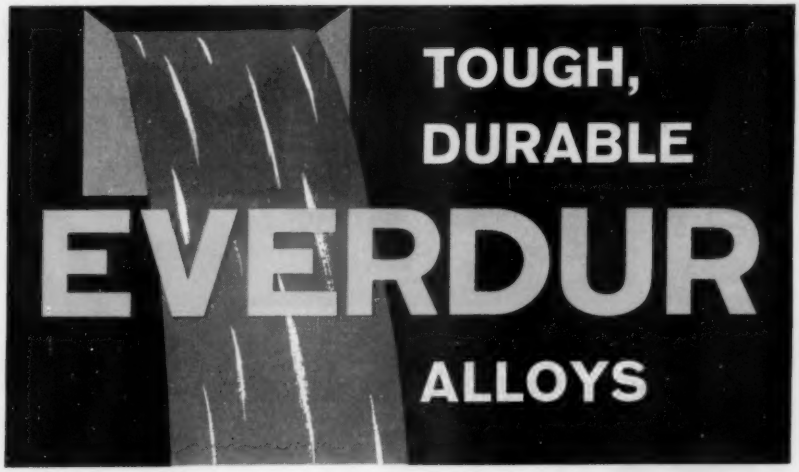
Also: Multiplier Photometers, Exposure Photometers for Photomicrography, Hemaglobinometers, Glossmeters, Polarimeters, Foot-Candle Meters, Interference Filters, Mirror Monochromators



highly resistant to wear and abrasion in sewage and water works systems

EVERDUR® copper-silicon alloys have excellent resistance to corrosion in all types of water works installations and at all stages of sewage treatment operations. EVERDUR equipment in the United States has been in service *without replacement* for 30 years and longer.

Easily fabricated EVERDUR provides high physical strength with lighter weight. It is used extensively in sewage systems handling corrosive wastes in screens, stems, manhole steps, guides, bolts, weirs, float chambers, troughs. And for water works equipment you will find EVERDUR alloys in long service as surface reservoir outlet screens and screen frames and as large diameter cylindrical well screens in drilled well supply systems. Other uses: spillway fittings, guides, seats and sealing strips. And don't forget EVERDUR Electrical Conduit for use in corrosive atmospheres.

Publication E-11 shows typical applications and other data. Write for your copy—or for assistance from our Metallurgical Dept. in selecting the proper corrosion-resistant alloys for your equipment. Address: Anaconda American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Canada. 61-811

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"Only The Best"

For ordering dependable and proven pipe line equipment, consult your latest Pollard Catalog #27.

Included in the #27 Catalog, and displayed on this page, are the M-Scope Transistorized Combination Leak Detector and Pipe Locator, Audio-Scope, Geophone Leak Detectors, T-10 Electronic Box Locator, Aqua Valve Box Locator and Magnetic Dipping Needles for locating service boxes.

Hundreds of water departments all over the country are using Pollard "one order" service. You, too, can enjoy the advantages of ordering from the nation's #1 source for dependable pipe line equipment.

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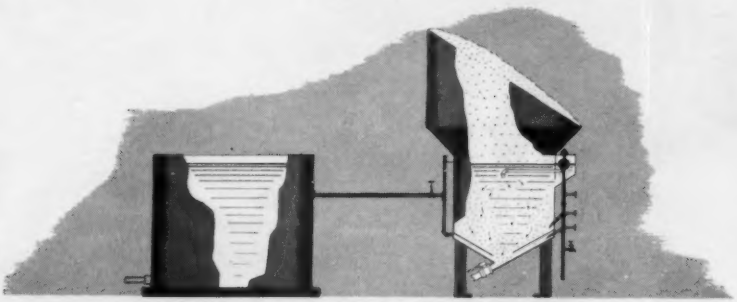
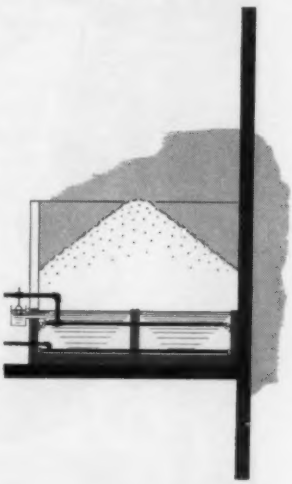


SALT STORAGE

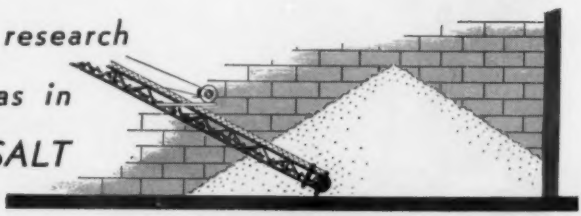
How it can affect design of water softening installations

The method used to store salt must be considered when planning a water softening plant. Dry salt storage, for example, requires different facilities from brine storage. And "wet storage" (dry salt stored under covering brine) has its own special design needs. Whatever method is chosen, however, its effect on plant design is greater than ever, since **more** salt and brine are needed in today's higher-capacity softening plants.



If you would like help in planning modern, large-scale salt-storage facilities, contact International Salt Company. With over 50 years of experience and continuing research in all phases of salt handling and brine production, International can suggest many new and practical ideas in connection with salt purchase, storage and dissolving for regenerating ion exchangers. This service is impartial and comprehensive. It costs you nothing.

Service and research are the extras in STERLING SALT



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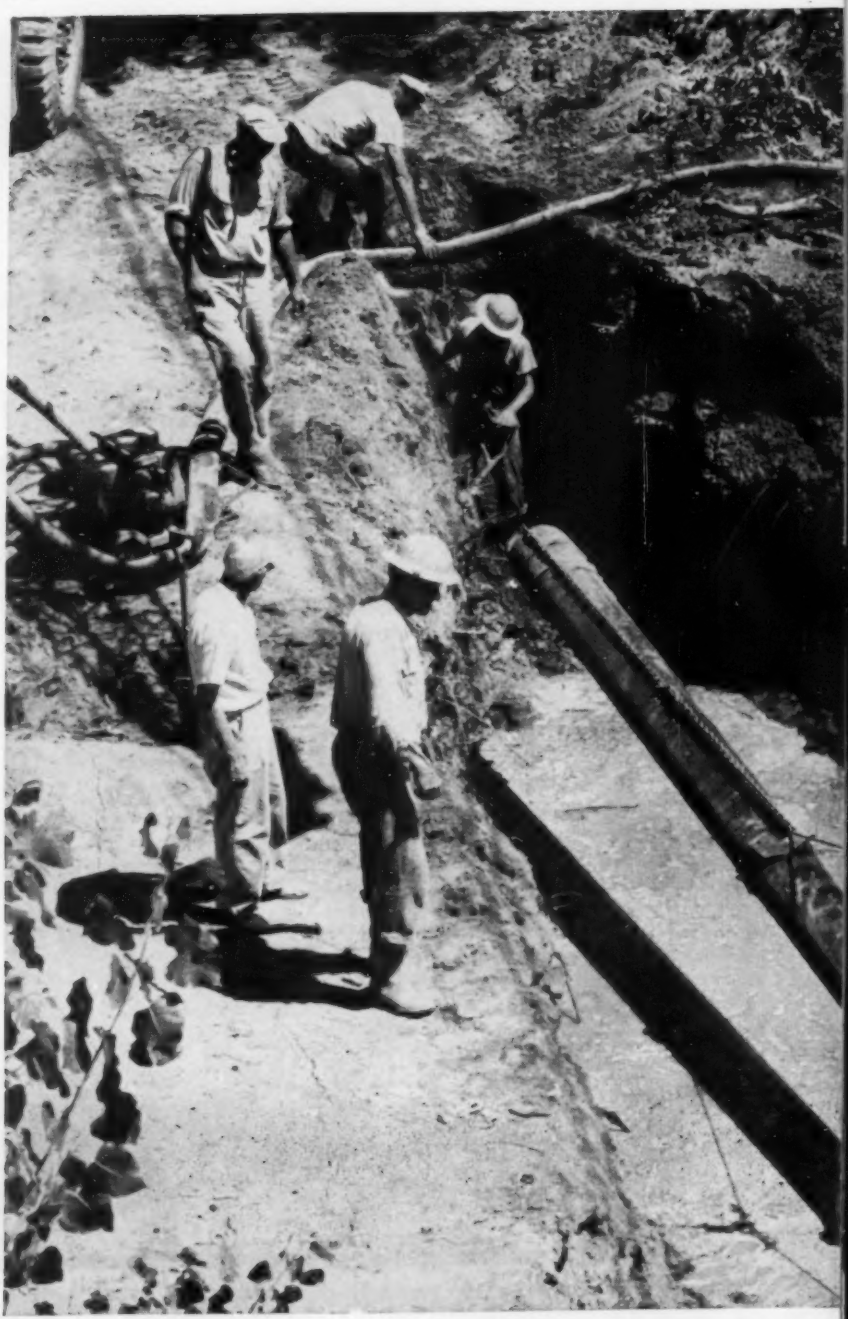
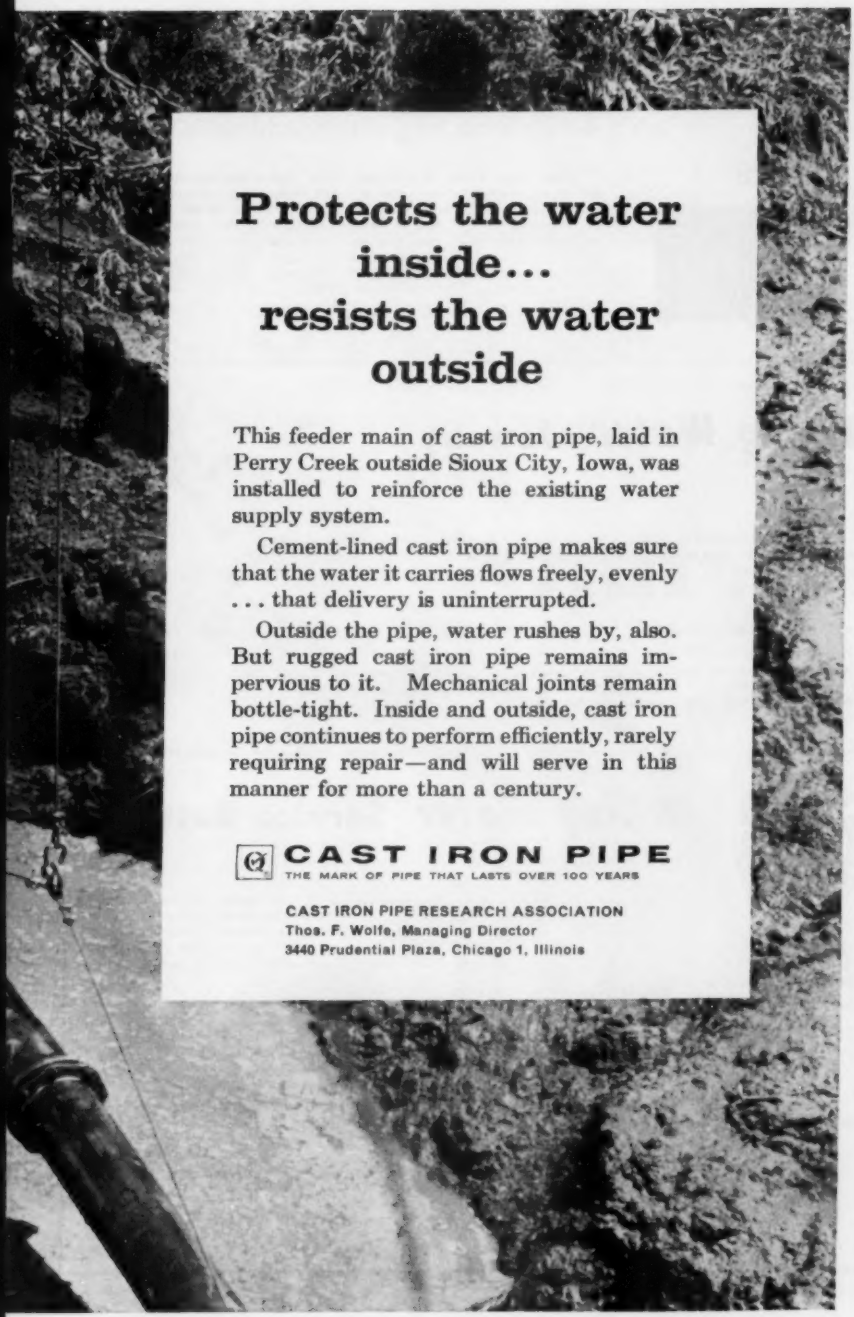




Protects the water inside... resists the water outside

This feeder main of cast iron pipe, laid in Perry Creek outside Sioux City, Iowa, was installed to reinforce the existing water supply system.

Cement-lined cast iron pipe makes sure that the water it carries flows freely, evenly . . . that delivery is uninterrupted.

Outside the pipe, water rushes by, also. But rugged cast iron pipe remains impervious to it. Mechanical joints remain bottle-tight. Inside and outside, cast iron pipe continues to perform efficiently, rarely requiring repair—and will serve in this manner for more than a century.

CAST IRON PIPE
THE MARK OF PIPE THAT LASTS OVER 100 YEARS

CAST IRON PIPE RESEARCH ASSOCIATION
Thos. F. Wolfe, Managing Director
3440 Prudential Plaza, Chicago 1, Illinois

what price water?

WHAT PRICE WATER? is a 12-page, 4x9-in. booklet that calls to the attention of the reader the real value of public water supply. Comparing 1940 prices of a number of other common items with today's, it also presents a comparison of the 1940 costs of water works facilities with present ones as an indication that water rates must be boosted. Designed to fit in a standard No. 10 business envelope, the booklet sells at prices ranging from 10¢ to 2½¢ per copy. Imprints of your name and address as well as your rate per thousand gallons or cubic feet can be provided on lots of 500 or more. Ask for sample.

Willing Water Jewelry

Since their introduction in 1954, the Willing Water jewelry items have been most popular as awards, gifts, and good will builders. Presenting a blue-faced Willie in full stride, the emblem has made a hit as a lapel button as well as a decoration on a number of jewelry items. Included in the list of items now available are:

AW-1	Lapel Emblem (screw-back) ..... $ .75	AW-8	Shortie Tie Clip (rhodium plated alligator clip) $1.85
AW-2	Lapel Pin (joint pin & safety catch) ..... .75	AW-9	Money Clip (rhodium plated) 2.75
AW-3	Key Chain (spiral mesh chain and spring-lock holder) 1.25	AW-10	Cuff Links (rhodium plated disks) 4.50
AW-5	Zippo Cigarette Lighter (brush finish, boxed).... 3.15	AW-11	Earrings (screw type) 2.50

Willing Water Service Buttons

The popularity of Willing Water lapel emblems has led to the design of a special button for recognition of tenure. The design shown at the left was prepared on the request of the Alliance, Ohio, Water Department, which now uses the service buttons. It is now available to you, with your company name engraved on it. Minimum order is 25 buttons or pins. On such an order a die charge of $17.50 is made for inserting your company name. The pins (with joint pin and safety catch) or buttons (with screw-back) are priced as follows:

Bronze	$1.00	10K Gold	$4.25
Sterling	1.50	14K Gold	6.75
Gold filled	2.00		

The minimum quantity (25) may be assorted as to years of service and as to metal used. Please specify clearly the number of each type required with pins (for female employees) and with screw backs.

AMERICAN WATER WORKS ASSOCIATION

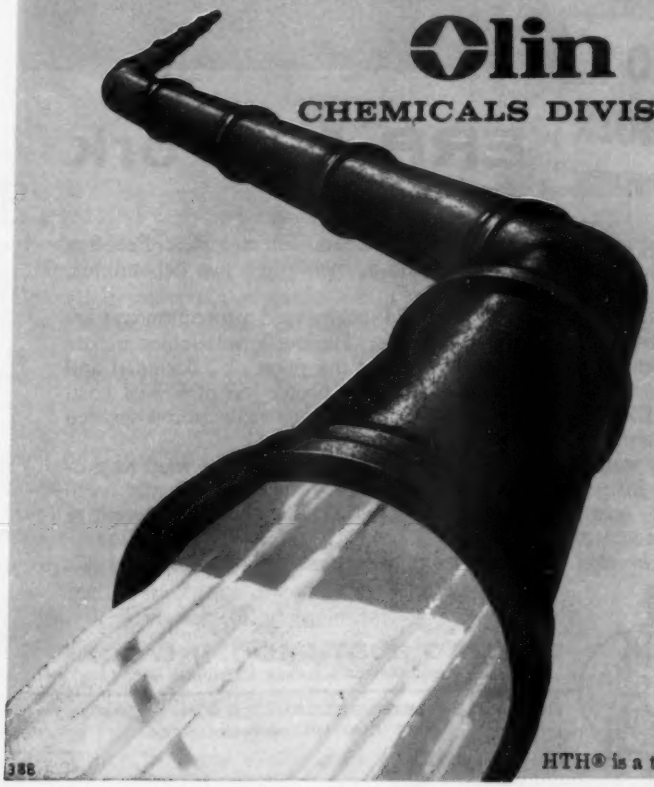
2 Park Avenue **New York 16, N.Y.**

Chlorination, right down the line. Dry, easy-to-use HTH Tablets—the modern way to chlorinate new mains . . . kill bacteria, algae and fungi fast. They release dependable, highly effective chlorine quickly . . . dissolve slowly to last longer. Economical, too—one tablet sanitizes many feet of pipe. HTH Tablets protect reservoirs, wells and filtration equipment, too. Come in convenient cans, pails and drums. Write for literature: **Olin Mathieson, Baltimore 3, Maryland.**

Here's to Health . . . **HTH**

Olin

CHEMICALS DIVISION



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HTH® is a trademark.

ERP At Work

This quiet scene should not mislead. Electro Rust-Proofing *is* hard at work. There's no hustle or bustle . . . just dependable, continuous cathodic protection.

Underneath this water an ERP-engineered protection system fights rust—fights maintenance costs. The battle was joined before installation. ERP Engineers surveyed the plant . . . designed and installed a system that gives maximum protection at lowest cost. And now ERP Service follows up. Continuous protection is assured . . . maintenance costs are the lowest ever.

If you want to stop trouble before it starts, if you want to protect your investment in steel structures—quietly, efficiently, economically—use Electro Rust-Proofing Systems. ERP is preventive maintenance at work.

We'll be glad to send more information. Write Dept. E-51.05

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SINCE 1935

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Journal

AMERICAN WATER WORKS ASSOCIATION

VOL. 53 • JULY 1961 • NO. 7

Water Hardness and Domestic Use of Detergents

Lloyd M. DeBoer and Thurston E. Larson

A paper presented on Mar. 22, 1961, at the Illinois Section Meeting, Chicago, Ill., by Lloyd M. DeBoer, Asst. Prof. of Marketing, College of Commerce, Univ. of Illinois, Urbana, Ill.; and Thurston E. Larson, Head of Chemistry Section, Illinois State Water Survey, Urbana, Ill.

EVERY housewife knows that the amount of soap or synthetic detergent she needs is determined, in part, by the hardness of the water she uses. This article reports the results of a study made to correlate varying degrees of water hardness with the detergent consumption of the people who use the water. Detergent savings effected by water softening are compared to the costs of reducing water hardness.

Considerations of convenience, cleanliness, maintenance of facilities, and life of clothes and linens are excluded from this study, although they are recognized as economically important. The importance of water hardness to commercial establishments, industries, and other establishments that use water for heating or air conditioning, is also beyond the scope of this inquiry.

Hardness Reduction and Removal

Aside from soap, which is a water softener as well as a detergent, and from synthetic detergents, which usually include softening agents as additives in the commercial product, there are several methods of reducing the hardness of domestic water. One is treatment by the water utility, either with lime (and soda ash) or with ion exchangers (such as zeolite) using salt as the regenerant chemical. The other is by home treatment with ion-exchange units, either owned and regenerated by the homeowner or rented and serviced by local water-conditioning agencies.

The municipal water utility procedure rarely reduces the hardness below 70 ppm, and usually limits the hardness to 100 ppm, so that the calcium hardness protects the distribution sys-

tem against loss of pipe capacity and against corrosion, thus eliminating the possibility of rusty water.

Utility treatment and home treatment for hardness reduction readily supplement each other.[1]

Previous Studies

A comprehensive study on soap consumption and water quality was conducted by H. W. Hudson and A. M. Buswell in 1931.[2] Since then, economic changes, the almost complete replacement of soaps with synthetic detergents, the wide use of new man-made fabrics, and the automation of cleaning processes have necessitated a revised appraisal.

The Hudson-Buswell study was conducted by the personal interview method at retail stores to obtain complete data on retail soap sales at four cities having different types of waters. After appropriate corrections for the surrounding trade area sales and other minor considerations, annual per capita soap consumption and costs were established. These figures were revised upward in 1948[3] by the application of a factor derived from the wholesale cost indexes for soap and soap products. At that time, synthetic detergents accounted for only a small percentage (about 12 per cent) of the domestic detergent consumption. At present, the national domestic sales of

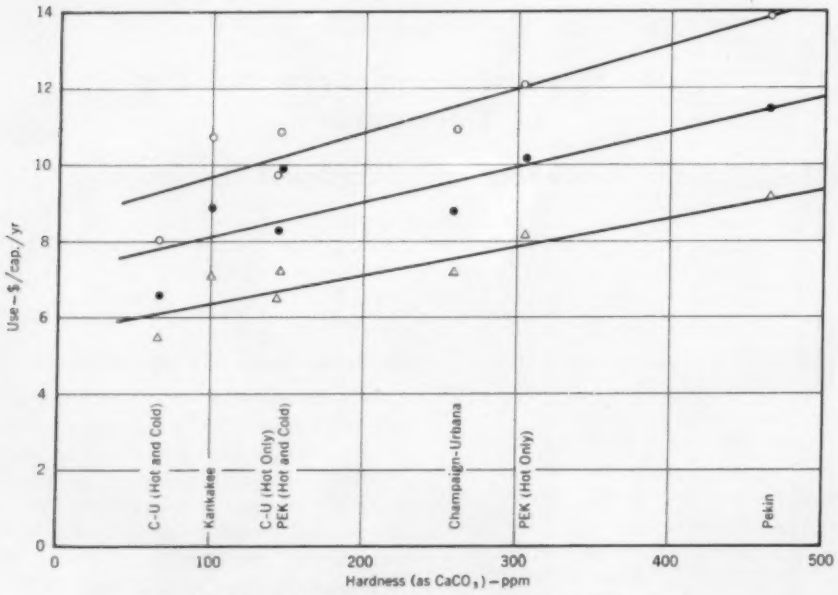

Fig. 1. Effect of Water Hardness on Use of Detergents

Savings per 100 ppm hardness for gross products (open circles) are $1.15; 90 cents per 100 ppm for total soap and synthetics (solid dots); 75 cents per 100 ppm for laundry detergents (triangles).

synthetics are roughly ten times the sales of soap.[4]

The advantages of synthetics with hard water are many, as demonstrated by their increasing use. As Aultman has pointed out,[5] however, their composition suggests that water hardness affects the quantity required for adequate cleaning. The heavy-duty, all-purpose products that comprise by far the largest segment of the market contain 30–50 per cent sequestering ingredients such as complex phosphates * to equal soaps in ability to remove dirt from heavily soiled clothes and in general cleaning.

These sequestering ingredients are also softening agents, because they react with calcium and magnesium, the hardness components of water. In hard water, therefore, these ingredients are decreased in effective concentration for their cleaning purpose. Thus more product is required in hard water than in soft water.

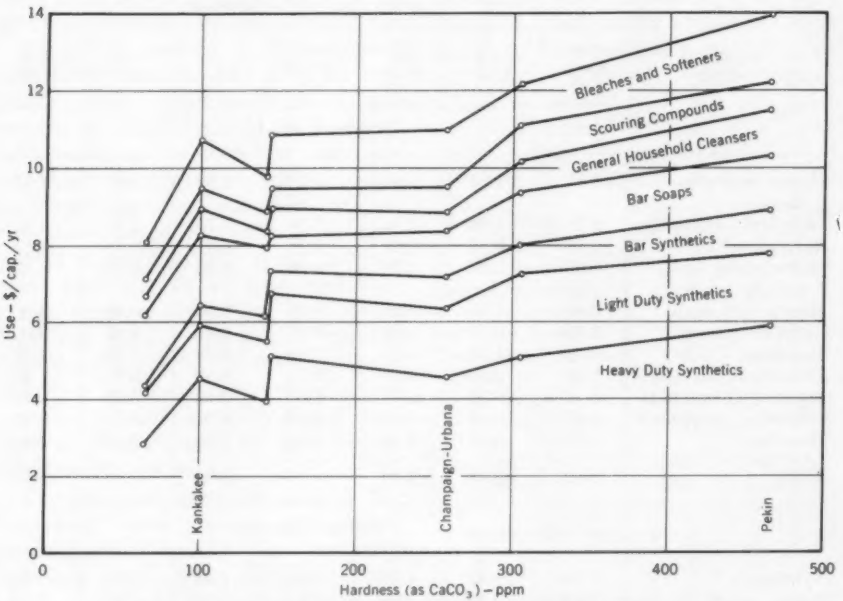

Fig. 2. Effect of Water Hardness on Use of Various Products

Heavy-duty synthetics comprise major portion of products used.

Because many families substitute or supplement synthetics and soaps with softening agents, scouring compounds, and bleaches, it is reasonable to expect that the consumption of these additives would also be related to water hardness. In this study, therefore, data on these products were also obtained.

* Usually sodium tripolyphosphate (STP) and tetrasodium pyrophosphate (TSPP), and more recently tetrapotassium pyrophosphate (TKPP) in liquid heavy-duty synthetics.

Method of Procedure

Three cities were chosen for the study: Kankakee (KKK), Champaign-Urbana (C-U), and Pekin (PEK), all in Illinois. At Kankakee, the water utility clarifies and softens water from the Kankakee River to a hardness of 100 ppm as well as chlorinating and treating the water for taste and odor removal.

At Champaign-Urbana, well water is treated for iron removal and is chlorinated. The weighted-average hardness, as determined from the pumpage and analysis of the water from wells used during the study, was 258 ppm.

At Pekin, no treatment is provided other than chlorination. The average hardness was determined from 48 samples collected twice monthly during the study, from five selected locations in the distribution system. Average hardness was found to be 465 ppm.

TABLE 1

Average Use of Products Per Capita Per Year

Product Classification	City and Type of Home Softening						
	C-U Hot & Cold	KKK None	C-U Hot*	PEK Hot & Cold	C-U None	PEK Hot*	PEK None
	Average use—$						
Heavy duty synthetics	2.84	4.54	3.94	5.11	4.59	5.07	5.85
Light duty synthetics	1.36	1.38	1.56	1.66	1.74	2.20	1.92
Bar synthetics	0.16	0.50	0.61	0.51	0.82	0.73	1.12
Dishwashing compounds	0.05	0.02	0.29	0.00	0.05	0.02	0.00
Heavy duty soap	0.46	0.19	0.24	0.00	0.06	0.01	0.05
Light duty soap	0.35	0.28	0.08	0.00	0.08	0.07	0.03
Bar soap	0.96	1.36	1.25	0.98	0.98	1.26	1.27
Household cleaners	0.45	0.69	0.36	0.71	0.50	0.83	1.22
Scouring compounds	0.49	0.58	0.53	0.50	0.68	0.90	0.74
Softening compounds	0.65	0.63	0.54	0.93	0.91	0.73	0.91
Bleaches	0.25	0.55	0.36	0.46	0.50	0.29	0.82
Total	8.02	10.72	9.76	10.86	10.91	12.11	13.93
	Average Cost—¢/oz						
Synthetics	1.94	1.82	1.89	1.84	1.84	1.86	1.88
Soaps	2.08	2.31	2.65	2.44	2.58	2.48	2.60

* Blend of 60 per cent softened hot water with 40 per cent unsoftened cold water.

In each of these three communities a panel of households was selected by probability sampling procedures. The number selected in Kankakee was 169; in Champaign-Urbana, 274; and in Pekin, 230. More households were selected than were necessary, as it was anticipated that there would be drop-outs during the study. The number of

households selected in Champaign-Urbana and Pekin were greater than in Kankakee, so that a sufficient number who softened some or all of the water could be classed as separate panels. In addition to dropouts, all households that did laundry for persons other than household members were eliminated in the correlation studies, as were those that used commercial laundries or laundermats.

Each household reported monthly, on a diary form, their purchases of the products included in this study. The time period covered by their reports was seven months, July 1959 to February 1960. The diary form was mailed to the household each month as a reminder to record each purchase. Purchase data were usually reported by brand of product, size, and cost. At the start and at the end of the time period covered by the study, a complete inventory of all soap and synthetic detergent products and other additives on hand was taken by trained interviewers. By use of these purchase data and inventory data, computations provided the amount and value of each class of product used by each household during the study.

The individual products used by the households were grouped into twelve product classifications for analysis: light-duty soap, heavy-duty soap, bar soap, light-duty synthetic detergent, heavy-duty synthetic detergent, bar synthetic detergent, general household cleanser, scouring compound, dishwasher compound, shampoo, package softener, and bleach. Information from manufacturers on the nature of their products and the type of cleaning job each was designed to perform served as the basis for this classification so that each group would be reasonably homogeneous on these two points.

Shampoo purchase records and questionnaire data on use of beauty parlors were considered separately.

It became evident early in the process of evaluating results that the assumptions on the hardness of home softener effluents were not valid. Therefore, in both Champaign-Urbana and Pekin, the hardness of the hot and cold water to the laundry was determined at 35 homes.

Four homes at Pekin and two at Champaign-Urbana that reported both hot and cold water softened were found to have softening only on hot water. After transfer of these panel members to the proper classification, the remaining members under the hot and cold classification were visited twice for additional samples for hardness determinations.

TABLE 2

Soap Use and Hardness*

City and Type Home Softening	Hardness (*ppm*)	Soap Use—Percentage of Consumption
Champaign-Urbana (hot and cold)	67	24.6
Kankakee (none)	100	17.6
Champaign-Urbana (hot)	143	15.6
Pekin (hot and cold)	145	8.6
Champaign-Urbana (none)	258	10.8
Pekin (hot)	306	10.8
Pekin (none)	465	9.9

* As distinguished from synthetics.

For the softened hot water classification, the average hardness was found to be 205 ppm at Pekin and 67 ppm at Champaign-Urbana. In the absence of definitive data it was arbitrarily assumed that 60 per cent hot water and 40 per cent cold water were

blended, or used alternately, for washing and cleaning purposes at homes where only hot water was softened. In this classification, therefore, hardness for Pekin was selected as 306 ppm and 143 ppm for Champaign-Urbana.

The average hardness of the samples from the hot and cold softened water classification was found to be 145 ppm at Pekin and 67 ppm at Champaign-Urbana.

The results of this study also showed a marked difference between the average hardness of home-owned softener effluents and serviced softeners. At Pekin, average hardness with home-owned softeners was 191 ppm, and 97 ppm with serviced softeners; at Champaign-Urbana, the average with home-owned units was 69 ppm, and 45 ppm with serviced units.

TABLE 3

Shampoo Use and Beauty Parlor Patronage

City and Type of Home Softening	Hardness *ppm*	Income Over $6,600 %	Beauty Parlor		Shampoo
			Patronage %	Average Annual Expenditure $	Average Annual Use Per Capita—$
Champaign-Urbana (hot and cold)	67	77	41.2	72.00	.86
Kankakee (none)	100	28	24.8	41.58	1.32
Champaign-Urbana (hot)	143	58	42.8	84.33	1.00
Pekin (hot and cold)	145	46	38.5	51.60	.88
Champaign-Urbana (none)	258	39	21.7	56.61	1.33
Pekin (hot)	306	50	50.0	59.35	1.31
Pekin (none)	465	36	15.8	42.40	1.59

Results

Figure 1 shows the dollar costs and the savings by hardness reduction for average per capita use of all the products tabulated. It should be noted that within each of the six hardness classifications per capita use varied by factors as high as ten. The vertical range of the statistical standard error is therefore quite high.

The slope of the line of best fit, as determined by the least squares method using the 398 families, indicates the savings in gross products affected by hardness reduction to be $1.15 per capita per 100 ppm hardness removed. The 95 per cent confidence limit for the seven average values was 68 cents. Therefore, if Champaign-Urbana water is treated for a proposed 75 ppm hardness, the per capita savings would be $2.10 per year (if no home softener is presently used), or $7.35 per year for the average family size. At Pekin the per capita savings would be $4.20 per year if the hardness were reduced to 100 ppm. As previously explained, neither of these figures includes the many additional monetary savings, besides the convenience, that would result from hardness reduction.

Also in Fig. 1, the per capita use of laundry detergent products alone is indicated. This category excludes bleaches, softening agents, hand soaps, and scouring compounds. These products are often used for car washing,

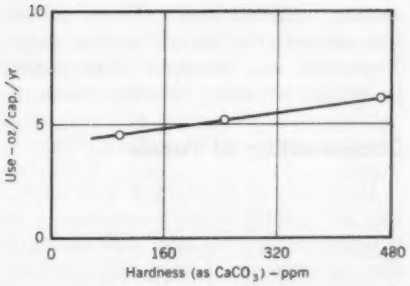

Fig. 3. Effect of Water Hardness on Use of Detergents by Unskilled, Craft, and Clerical-Sales Workers' Families

Use is for gross products excluding bleaches and softening additives by panel members that provided no home softening. Savings are 91 cents per capita per 100 ppm hardness per year.

dish washing, and other cleaning purposes as well as for laundry. Here the slope of the line represents 75 cents savings per capita per year per 100 ppm hardness reduction. This is generally representative of the synthetic detergents and soaps exclusive of hand and bath products.

The middle line in Fig. 1 represents all soap and synthetic detergent products including bar products and general household cleansers. The savings by hardness reduction is indicated to be 90 cents per capita per year per 100 ppm hardness reduction.

The additive reported by the American Institute of Laundry and home economics experts to cause the greatest detrimental effect on clothes is bleach. The consumption of bleach increases, in general, with increasing hardness, reflecting the greater need for this additive when hard water is used.

Figure 2 and Table 1 show the breakdown of the use of gross products by product classifications. Synthetics represent most of the use, with the heavy-duty products predominating. The heavy-duty synthetics are the least expensive, costing 1.5 cents per ounce, whereas the light-duty synthetics at 2.6 cents per ounce, and bar synthetics at an average cost of 4–5 cents per ounce, have lesser general utility. The classification of heavy-duty detergents does not include the general utility products such as "Mr. Clean," "Handy Andy," and "Lestoil" which are also synthetic products and are often used for laundry purposes.

It will be noted in Table 1 that the use of light- and heavy-duty soaps is negligible in all three Pekin categories and in the Champaign-Urbana unsoftened water category. Of the total soap and synthetic detergent products, exclusive of general household cleansers, the percentage of soap use increases with decreasing hardness (Table 2).

Shampoo and Beauty Parlor

Approximately 90 per cent of the panel members reported shampoo purchases. Table 3 shows that the use of shampoo seems to bear a fair rela-

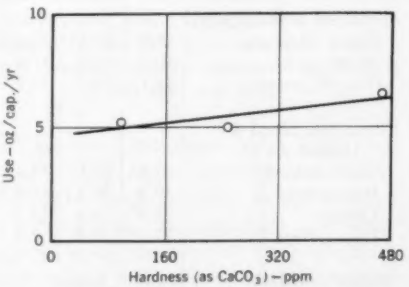

Fig. 4. Effect of Water Hardness on Use of Detergents by Families With Incomes of $4,200–$10,400

Use is for gross products excluding bleaches and softening additives by panel members that provided no home softening. Savings are 80 cents per capita per 100 ppm hardness per year.

tionship to water hardness. Any analysis of shampoo use, however, must also consider the 15–50 per cent of the households that also patronized the beauty parlor.

It will be noted that 38–50 per cent of those who soften their water patronized the beauty parlor and that 46–77 per cent of these groups were in higher income classifications. These groups coincide with the lower shampoo usage. Therefore, the shampoo data cannot be related to water hardness alone.

TABLE 4

Comparison of Socio-Economic Characteristics

Characteristic	C-U	PEK	KKK
	Panel Families in Each City—%		
Washer Used			
Automatic	59.6	61.2	61.0
Conventional	40.4	38.8	39.0
Income			
Under $4,200	19.9	17.6	28.6*
$4,200–10,399	61.0	72.0*	64.8
$10,400 and over	15.9*	9.9	6.7
Number of Children			
None	33.1*	26.0	30.5
One	24.5	24.7	15.2
Two–three	31.1	40.1	37.2
Four or more	11.3	9.2	17.1*
Age, Head of Household			
Under 30 years	15.2	22.6*	12.4
30–50 years	50.3	47.2	47.6
Over 50 years	33.1	28.2	37.1
Education, Head of Household			
Grade school	10.6	24.6	37.1
High school	39.8	56.4	41.9
College	27.8*	13.4	14.3
Post college	17.2*	2.8	2.9
Occupation, Head of Household			
Unskilled	11.3	12.0	16.2
Craftsman	33.8	45.1	37.2
Salesman, clerical	9.9	15.5	11.4
Professional, managerial	40.4*	15.5	21.0
Housewife	1.3	1.4	3.8
Retired	3.3	7.7	9.5

* Specific features of distinction.

Comparability of Panels

In a study of this type it is necessary that the panels in each community be comparable so that any differences in the consumption of soap and synthetic detergents established among them can be attributed to water hardness and not to differences in panel characteristics. Such comparison is made between the entire panels in each community irrespective of home softening practices, because home softening practices also are determined to an important extent by the status and needs of the individual family as well as by water hardness.

The comparability of the panels was examined as to the type of washing machine used, total family income, number of children, and the age, education, and occupation of the head of the household. These factors are readily available from the study, which was designed to reveal important variations in consumption that might arise among families of a community when grouped by each of these characteristics.

The data in Table 4 indicate that each panel provides a reasonably good cross section for each characteristic, in that all major subgroups are adequately represented. They are particularly comparable as to type of washer used, with 60–61 per cent of all panel members in each community using an automatic washer. For each of the other characteristics, relatively more of the panel members in one community than in another belong to certain subgroups. Specific features of distinction are starred.

The table shows that considerable intra-correlation among these charac-

teristics is evidenced in Champaign-Urbana with its higher income, its higher education level, and its larger percentage of panel members with a professional or managerial occupation.

Further analysis of the characteristics of those panel members in Champaign-Urbana and Pekin that practice home softening indicates that they are more likely to own dishwashing machines and automatic washers, to have higher incomes, to be in older age groups, to have a college or post-college education, and to have a professional or managerial occupation. This appears to be a decided pattern for those who soften their water.

Analyses by Panel Characteristics

The data, grouped according to selected socio-economic characteristics, were examined to determine the existence of any relationships with the per capita consumption to total products. These analyses were made only for those who do not practice home softening. The number of panel members in many specific socio-economic groups, such as the clerical-sales occupation, was too small for meaningful analysis.

The per capita use for total products was found to be less for those using conventional washers than for those using automatic washers. The heavy- and light-duty soaps and synthetics would be the products most influenced by this factor. It is clear from Table 5 that there is much greater use of these products by those using automatic washers. This relationship is not significantly altered if general household products are included.

By grouping the craftsman, unskilled, and clerical-sales occupations, which represent 65–78 per cent of the panel members using unsoftened water, a direct relationship to hardness is indicated (Fig. 3) for ounces per capita use of products other than bleach and softening additives, and for dollars per capita per year use of gross products. Use by the professional-managerial occupations was greater at Kankakee and Pekin and less at Champaign-Urbana.

Similar but less conspicuous relationships are noted (Fig. 4) for the $4,200–$10,400 income group, representing two-thirds of the panel families at each city, and for the 30–50-year age group, representing 48–50 per cent of the families at each city (Fig. 5).

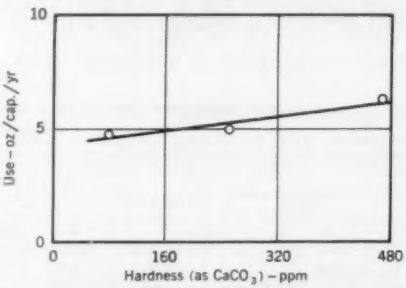

Fig. 5. Effect of Water Hardness on Use of Detergents by Families With Head of Household 30–50 Years Old

Use is for gross products excluding bleaches and softening additives by panel members that provided no home softening. Savings are 96 cents per capita per 100 ppm per year.

There is a tendency for a slight decline in per capita consumption when there are more children in the family.

Inconsistent relationships between education of the head of the household with usage suggests that this factor has little influence on consumption.

Using the six selected socio-economic characteristics, the greatest number of families that had identical characteristics was found to be eight of the 398 families with more than 1,500 individuals in the three cities. These families use an automatic washer; the

head of the household has a craftsman occupation; he is 30–39 years of age; he graduated from high school; they have 2 children; and they have a family income of $6,600–$10,399. These families were also identical in family size (only one had a fifth member for 82 per cent of the study period), and none of them practiced home softening. Two families were from Kankakee and three were from each of the other communities. Thus, these families are as identical as they could be from the data used for description.

It is immediately clear from Fig. 6 that the total consumption of all products in dollars varies substantially among these eight families, from a low of $7.02 per capita per year to a high of $15.80. There is also substantial variation in many of the product classifications that go into this total. Heavy duty synthetics, the largest product group for all families but one, ranges from $2.87 to $9.90. Heavy-duty plus light-duty synthetics range from $4.28 to $10.85. Even among the less important product groups there is considerable variation. For example, one family is a heavy user of bar detergents, another of bar soap, another of scouring compounds, and still another of bleach and softening compounds. There was no consistency in total consumption among the families nor among the products consumed by any two of these families. Therefore, it is evident that no one family, even within a given set of socio-economic characteristics, can be considered typical with regard to use of detergents.

Comparability of Water Quality

Considerable speculation may be made on the possible differences between the three cities. Aside from hardness, the general characteristics of the waters are different, as is noted in Table 6.

TABLE 5

Use of Light- and Heavy-Duty Soaps and Synthetics With Automatic and Conventional Washers

City	Hardness *ppm*	With Conventional Washer			With Automatic Washer		
		No.	oz/cap./yr*	$/cap./yr	No.	oz/cap./yr*	$/cap./yr
Kankakee	100	41	353	5.49	64	405	6.99
Champaign-Urbana	258	50	306	5.49	56	423	7.35
Pekin	465	48	365	6.64	48	545	8.54

* Excluding bleach and softening products.

The hardness of the Champaign-Urbana water is carbonate with some sodium bicarbonate. On heating, carbon dioxide is released and calcium carbonate alone is precipitated in colloidal form.

Pekin water has appreciable noncarbonate hardness, but on heating and loss of carbon dioxide, again only calcium carbonate is precipitated, more of it than in Champaign-Urbana water at hot-water tank temperatures.

Kankakee water also has significant noncarbonate hardness, but the determined pH range of 9.2 to more than 10 means that no carbon dioxide will be released on heating; however, because the water is saturated with mag-

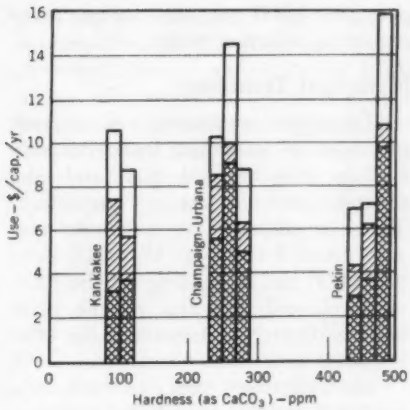

Fig. 6. Use by Eight Families Having Identical Socio-Economic Characteristics

Data show great variability in total use and in use of the different product classifications. Heavily shaded sections represent heavy-duty synthetics. Light-shaded sections represent light-duty synthetics. Blank sections represent all other uses.

nesium hydroxide as well as calcium carbonate, both will precipitate on heating. A considerable proportion of magnesium hydroxide will precipitate because of the high temperature coefficient for the solubility product constant.

One of the properties of precipitated magnesium hydroxide is its great adsorbing power. Also, contrary to the effect on calcium carbonate, trace concentrations of polyphosphates do not prevent the tendency of magnesium hydroxide to precipitate. Therefore, in laundry rinsing, for example, the precipitation of traces of magnesium hydroxide may adsorb traces of suspended soil and redeposit them onto the clothes. There are no data in the literature to confirm this hypothesis, nor are there data to disprove it.

Changes in Use and Cost

For comparative purposes, the total per capita soap and synthetic detergent use in ounces for this study is shown in Fig. 7 with that obtained in the Hudson-Buswell [2] retail sales study in 1931. The data indicate that the present day consumption is about 120 oz per capita per year less than 30 years ago. This might be attributed to the greater efficiency per unit weight of synthetics as compared to soaps. Consideration should also be given, however, to improved working conditions and to the diminished burning of coal, the smoke and dust of which may have formerly soiled things faster.

The cost of soap and detergent products, as for all products, has increased considerably since 1931, from 12 to 24 and 40 cents per pound; therefore, the present day costs for these cleaning products range from approximately

TABLE 6

Analyses of City Waters

Constituent	KKK	C-U	PEK
	Concentration—*ppm*		
Iron	trace	trace	trace
Manganese		0.0	trace
Calcium	20.7	57.0	123.1
Magnesium	11.7	28.0	46.0
Ammonium (NH_4)		3.0	trace
Sodium	44.9	35.0	9.2
Silica (SiO_2)	7.6	18.2	18.0
Fluoride		0.3	
Boron		0.4	
Chloride (Cl^-)	17	2.0	36.0
Nitrate (NO_3)		0.2	14.2
Sulfate (SO_4)		7.6	142.8
Alkalinity (as $CaCO_3$)	40	332	306
Hardness (as $CaCo_3$)	100	258	497
Total minerals	278	348	611
pH	9.7	7.5	7.3

$3.75 to $4.50 per capita per year more than in 1931 (Fig. 8). If there were no synthetics and if soaps were used at the same rate as in 1931 at a 1960 gross price of 32 cents per pound, the savings for 100 ppm hardness reduction would be $1.60 per capita per year. It is therefore evident that synthetics have particularly benefited users of harder water, although substantial savings of synthetics are to be realized with hardness reduction.

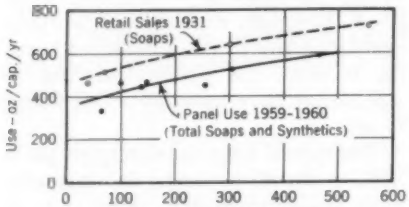

Fig. 7. Effect of Water Hardness on Weight Use of Soaps and Synthetics in 1931 and 1959–1960

Data show present consumption to be about 120 oz per capita per year less than 30 years ago.

Costs for Hardness Reduction

The gross savings indicated by this study may be compared with the per capita hardness reduction cost per 100 ppm per 1,000 gal by three methods of hardness reduction.

The average domestic consumption of water may vary 40–60 gpcd, of which it is generally assumed that about 27 gpcd, or 9,850 gal per capita per year, are used for purposes requiring softened water, such as laundry, bathing, cleaning, and cooking.

The gross purchase savings in additives per capita per 100 ppm hardness reduction have been indicated as $1.15 per year, or per 9,850 gal, which is approximately 11.7 cents per 100 ppm per 1,000 gal used for purposes requiring softened water.

Municipal Treatment

Municipal treatment, of course, processes all water and treats for purification, iron removal, taste and odor control, and corrosion prevention. The cost allocated to softening may vary from 5 cents to 15 or 20 cents per 1,000 gal, depending on the hardness removal, the size of the plant, and the degree of treatment for other improvements.

The effective cost of municipal hardness reduction may be calculated by the following equation:

$$\frac{100AE}{BC} = \text{cents per 100 ppm per 1,000 gal}$$

in which A is cost of water charges allocated to hardness reduction in cents per 1,000 gal; B, average daily per capita use of water only for purposes requiring soft water in gallons; C, reduction of hardness in parts per million; and E, average daily per capita water use in gallons.

Therefore, at a 5-cent cost for hardness reduction from 250 to 75 ppm, and a per capita water use of 50 gpcd (of which 27 gpcd are for softened water purposes), the increment for hardness reduction would be 5.3 cents per 100 ppm per 1,000 gal.

If the hardness reduction were 400 ppm at an allocation of 20 cents per 1,000 gal for municipal treatment, the effective cost would be 9.3 cents per 100 ppm per 1,000 gal.

Home Softening

The usual commercial salt requirement for regeneration is about 0.4 or 0.5 lb per 1,000 grains of hardness, and for domestic home-owned softeners 1–2 lb per 1,000 grains is usually used in order to obtain minimum fre-

quency of regeneration. The minimum salt requirement for the regeneration of water softeners is 0.3 lb per 1,000 grains. This figure is based on proper application and backwashing with certain exchange materials of high regeneration efficiency at this level.

The per capita cost of salt may be calculated from the following equation:

$$5.85AS = \text{cents per 100 ppm hardness reduction per 1,000 gal}$$

in which A is cost of salt in dollars per 100 lb; and S, salt use in pounds per 1,000 grains of hardness reduction.

Assuming that the regeneration step takes place at the time that the exchange capacity of the softener becomes exhausted, a minimum of 1.75 lb of salt is required for each 100 ppm hardness per 1,000 gal of water. At a domestic price of $2.00 per 100 lb, the minimum cost of salt may be calculated to be 3.5 cents per 100 ppm hardness reduction per 1,000 gal. With an average home use of 1 lb salt per 1,000 grains, the cost would be 11.7 cents per 100 ppm hardness reduction per 1,000 gal.

Because the salt requirements do not represent the total cost of home softening, an estimate for amortization of the water softener should be included. The amortization cost may be calculated from this equation:

$$\frac{100{,}000\left[\left(\frac{A}{E}\right) + .025A\right]}{3.65BCD} = \text{cents per 100 ppm per 1,000 gal}$$

in which A is cost of softener in dollars; B, daily per capita use of softened water in gallons; C, hardness of water in parts per million; D, number of household members; and E, life of softener in years.
and the lost interest on the investment is 5 per cent per year.

At a softener cost of $250 and at a 10-year amortization period, this cost would be about $31.25 per year (depreciation plus 5 per cent on investment). For a four-member family using 27 gpcd of softened water, the cost would be 80 cents per 1,000 gal. If the water had 250 or 500 ppm hardness, the cost would be 32 or 16 cents, respectively, per 100 ppm hardness reduction per 1,000 gal. For a two-member family these figures would be doubled. The true cost of home softening is the sum of the salt requirement and the amortization cost.

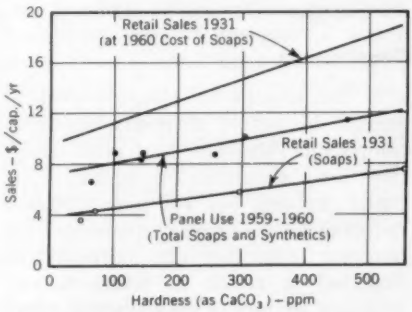

Fig. 8. Effect of Water Hardness on Sales of Soaps and Synthetics in 1931 and 1959–1960

Data show present sales range from approximately $3.75 to $4.50 per capita per year more than in 1931.

Serviced Softening

The charges for serviced softening include the cost of salt, the rental or amortization of the softener, and service.

The cost of serviced softening per 100 ppm hardness reduction per 1,000 gallons may be calculated from the following equation:

$$\frac{100{,}000A}{3.65BCD} = \text{cents per 100 ppm per 1,000 gal}$$

in which A is annual service charge in dollars; B, daily per capita use of

softened water in gallons; C, hardness of water in parts per million; and D, number of household members.

Thus for a family of four using 27 gpcd with 250 ppm hardness water and a service charge of $60 per year, the cost is 61 cents per 100 ppm hardness reduction per 1,000 gal, and for a family of two with 200 ppm hardness and a service charge of $42 per year, the comparable cost is $1.07.

Thus the annual per capita cost per 100 ppm hardness reduction can be determined by multiplying the calculated cents per 100 ppm hardness reduction per 1,000 gal by 9.85.

Conclusions

1. The savings for soaps, synthetics, general household cleansers, scouring compounds, bleaches, and other additives used were found to be $1.15 per capita per year per 100 ppm hardness reduction. Municipal treatment for hardness reduction can normally be expected to result in detergent and additives savings of more than the cost increment for treatment when the domestic per capita consumption is near 40–60 gpd.

2. The general replacement of soap with synthetic detergents has introduced a decrease in pounds per capita consumption since 1931. This alone has largely resulted in a savings at Kankakee, Champaign-Urbana, and Pekin approaching $3.80, $4.75, and $6.10 per capita per year, respectively, if soaps were still the only detergent products available.

3. The percentage of synthetic detergent use, relative to soaps, increases with greater hardness in water used.

4. The major cost of home softening is in amortization and service charge, and decreases with use of harder waters and with increasing use of the softened water. This is similar to the amortization cost that may be attributed to automobile driving mileage per year; because the depreciation per year is a fixed charge, the cost per mile of amortization decreases with more miles.

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Development and Administration of Los Angeles County Water Ordinance

John A. Lambie

A paper presented on Oct. 26, 1960, at the California Section Meeting, Long Beach, Calif., by John A. Lambie, Los Angeles County Engr., Los Angeles, Calif.

THE continued, rapid growth of population in Los Angeles County has made it increasingly necessary to serve water adequately and properly to nearly 6,000,000 inhabitants. Perhaps more than any single factor, an adequate supply of water is most important to the orderly development of Southern California.

By the year 2000, it is predicted that 23,000,000 people will be living in the area now known as Southern California. Los Angeles County, formerly the leading agricultural county in the United States, will be the hub of this giant megalopolis.

At the present time, Los Angeles County is served water by several hundred water purveyors whose agencies vary politically, legally, and physically. Many of these companies began as water systems for irrigation of orange groves and farmlands. For some companies, the change to primarily domestic service has come about rather catastrophically. It has been necessary for the majority of the water utilities to rely more and more on imported water to supply the increasing demands placed on the systems by suburban development.

Of the hundreds of water agencies within the county, about half are mutual water companies, self-regulating and owned by their members. The other half consists of municipally owned systems, county water districts, and irrigation districts with their own boards of directors, commercial water companies operated on a profit basis, and county water utility districts. Overlying the area served by many of these water utilities are municipal water districts formed to supply wholesale water to the retailers. The multiplicity of entities makes the regulation of water agencies complicated.

State Regulations

Acting in the public interest, California has instituted some controls over utilities supplying water for domestic consumption. Privately owned water companies operating in accordance with regulations of the California Public Utilities Commission must serve a dependable supply of water for domestic use at approved rates, but these companies are not regulated with regard to water supply for fire protection. The commission is primarily concerned with the establishment and regulation of cost rates. The primary concern of state and county health officers is that water supplies be safe and potable. In spite of state regulations, the fact is that many water systems in Los Angeles County are deficient with respect to materials, size of

pipe, and construction. Mutual water companies, in particular, lack formal governmental control.

Fire Protection

In many instances, the capacities of water supply systems in Los Angeles County are inadequate to provide enough water for fire protection. Los Angeles County now has a Class 2 fire department; only one other fire department in the county has a better rating. But a study of 29 NBFU surveys within the jurisdictional area of the Los Angeles County Fire Department indicates that there are no Class 1 or 2 water systems. The surveys rate 14 per cent of the systems as Class 3; 69 per cent as Classes 4 and 5; and 17 per cent as Classes 6, 7, 8, and 9. Of the 29 surveys made, 21 per cent rated water systems so poor that additional deficiency points were assigned the overall grading to compensate for the divergence in class between the fire department and the water supply.

An example of loss due to fire as a result of an inadequate supply of water occurred in July 1960. A one-story frame and stucco food market was a total loss. The building value loss was set at $25,000; the loss from foods and miscellaneous items was $70,000. The required fire flow for the area is 1,500 gpm. The flow available, 462 gpm, came from two wells pumping through a deadend 6-in. diameter water main. Although eight hose lines were laid to the fire, the available flow was such that only two hose lines could be operated at one time. As a result, the flow of water had to be continually switched from hose line to hose line in an attempt to extinguish the fire and protect exposed areas as well. Fire-fighting forces were unable to use the proper tactics for combating the fire.

County Water Works Districts

In the past, "county water works districts" have been formed to provide an adequate water supply in areas served by substandard systems. Typical of these districts is Waterworks District 22, Liberty Acres. On Jun. 24, 1952, the Del Aire Annex was added to Waterworks District 22 as a result of an election, at which time the residents also approved the authorization of a bond issue for the purpose of acquiring the Airways Water Co. (a publicly owned utility) and for providing the necessary water system improvements in the Del Aire zone of the district.

Funds were used to purchase the company and to replace undersized and deteriorated water mains constructed of seamless tubing during World War II. Recently, a construction program was completed wherein all water mains of the company were replaced with new 6-in. and 8-in. diameter asbestos-cement water mains, providing greatly improved water service to consumers.

Other areas have found it necessary to solve their water system problems by annexing to cities or districts with adequate water supplies. Some water companies have been purchased by private utilities and their systems improved. This has been a slow development, proceeding aimlessly without plan or accomplishment. Annexation or purchase usually occurs after a water system fails and no water is available.

County Board of Supervisors

The Los Angeles County Board of Supervisors formally recognized the

need for properly constructed water systems within the county as early as 1946. At that time, the county Public Water Supply Advisory Board was requested to consider the drafting of county standards for water system construction. Although several useful actions were taken by the advisory board, it did not succeed in establishing design standards.

After hearing continuing complaints as the population of the county increased, the board of supervisors, in its desire to protect the public, instructed the county engineer, forester and fire warden, and county counsel to prepare an ordinance regulating the installation of water mains and water supply systems required for unincorporated areas of the county for domestic, fire protection, industrial, and commercial uses. The board instructed that the ordinance contain minimum standards pertaining to unregulated systems that provided an inadequate supply. In adopting this order, the board considered that the construction of water mains and water facilities is a public improvement, like roads and other utilities, and that the construction and design of water mains and utilities were not regulated by the county. State agencies exercised only limited jurisdiction over agencies authorized to convey and sell water.

A draft of the ordinance was presented to the board of supervisors on Feb. 4, 1960. Prior to this time, approximately 1,000 copies of the draft had been circulated among interested persons, resulting in a considerable amount of constructive criticism. In addition, insofar as time had permitted, meetings had been held with interested groups to explain the proposed ordinance and to obtain further comment. But more work had to be done.

At the public hearing on Feb. 4, 1960, the board of supervisors, acting on the county engineer's recommendation, appointed an ordinance study committee representative of mutual water companies, public water districts, home builders, business men, and interested county departments. The county engineer, with the aid of this committee, was to review the ordinance draft and submit to the board a final copy for adoption.

County Engineer

Meeting once each week with the appointed citizens committee for a period exceeding 3 months, the county engineer thoroughly reviewed all facets of an ordinance regulating water system construction. When the preparation of an ordinance was considered, four principal areas of concern in the development of adequate standards were defined:

1. The administrative procedures for the ordinance provisions and regulations would be at a minimum.
2. The purpose and scope of the ordinance would be the application of minimum regulations to performance, materials, and methods of construction for water systems in unincorporated territory.
3. The ordinance would apply equally to all water companies within the unincorporated territory of Los Angeles County.
4. The regulations would govern (1) the performance of water systems and (2) construction methods and materials.

Administration

The county engineer believed that ordinance provisions should be as self-regulating as possible. The water industry readily agreed to the concept

of mutual responsibility and cooperation because this approach would eliminate delays and duplication of paper work and would reduce the cost to the county for the administration of the ordinance.

Several approaches to the problem of administration were considered, including:

1. A method whereby experienced professional engineers qualified in water system design could, after an examination of plans and specifications, be certified to issue authorizations permitting water companies to proceed with the construction of new facilities

2. A method whereby approved water companies with a certificate from the state health department would be certified and authorized to proceed with the construction of water system facilities.

The latter method was the one best suited for use, for the consensus was that ultimate responsibility for water system design, construction, and operation should rest with the water purveyor; therefore, the authority for design and construction should also rest with the purveyor.

To accomplish the purposes set forth by the county engineer—namely, that administrative details be at a minimum and that the industry be as self-regulating as feasible—four methods of authorization were developed and written into the ordinance draft:

1. *Water utility certification.* A water utility having a permit from the state health department could, by filing a form with the county engineer agreeing to abide by the terms of the water ordinance, be certified to proceed with all water system construction without further recourse to the county. The form developed for the ordinance is as follows:

Sec. 151. *Water Utility Certificate of Registration.* A person to whom constitutionally this ordinance can apply shall not construct any portion of a water system which is subject to the provisions of this ordinance without first having obtained a Water Utility Certificate of Registration. Such registration may be accomplished by filing with the Engineer the following form [space is here provided for the date, name of utility or person, and the address]:

1. I have a valid permit or have applied for a permit from the State of California, Department of Public Health, to operate a water system, a copy of which is attached.

2. I am familiar with the terms of the Water Ordinance and I agree to abide by the terms therein.

3. The persons in responsible charge of this water utility are [space is here provided for listing the persons involved and for the pertinent signature].

Such Water Utility Certificate of Registration shall be filed, in triplicate, with the Engineer, and upon receipt thereof, the Engineer shall endorse one copy and return it to the water utility. Upon receipt of the endorsed copy, the utility may proceed with the design and construction of its water system which comes within the scope of this ordinance.

Within 30 days after any change of the persons responsible in charge of the water utility, it shall so notify the Engineer in writing. The water utility shall renew the Certificate of Registration every 5 years.

2. *Water utility authorization.* Water utilities not certified and contemplating water main extensions would be required to submit plans and specifications for the work to the department of county engineer, so that they may be checked for compliance with the ordinance. If plans and specifications showed that the proposed work would meet the requirements, a certificate of authorization would be issued.

3. *Water service for new subdivisions.* Plans and specifications for water service to new subdivisions would be checked by the county engineer as required by subdivision ordinance. In addition to the requirement for plans and specifications, the applicant would furnish a certificate from a water utility stating that the proposed system could be operated by the utility.

4. *Water service for individual sites.* Water service for individual building sites would be checked in accordance with an amendment to the building ordinance which requires that a certificate of adequacy of water be submitted with the application for a building permit. The building code amendment is as follows:

Sec. 307. *Fire Protection.* Except as otherwise provided by this section, every application for a building permit shall be accompanied by:

a. A certificate from a water utility that it can supply water to the proposed structure in compliance with Ordinance No. 7834, entitled "Water Ordinance," adopted on Aug. 2, 1960, or

b. A certificate from the Forester and Fire Warden that there is, or is under construction, a private water supply which, in his opinion, is adequate for fire protection.

c. A certificate from the Forester and Fire Warden that there is a natural or artificial body of water so located that adequate water for fire fighting can be obtained therefrom.

Exceptions. A certificate is not required:

1. For accessory buildings
2. For alterations of, or additions to, existing structures
3. Group I occupancies where the required area is not less than 2.5 acres and there is not to exceed one dwelling for every 2.5 acres
4. In any area in which the County Engineer finds that one or more water systems exist serving the entire area which water systems comply with said Ordinance No. 7834.

Scope of Ordinance

During the study of the legal framework under which an ordinance regulating water systems in the county of Los Angeles could be drafted, several considerations were reviewed. The first of these was that privately owned water companies operating under the jurisdiction of the public utilities commission, a state regulatory board, were exempt from regulations imposed by county ordinance in the area so regulated by the state. There was no question in regard to this legal fact. But members of the commission expressed, unofficially, an opinion about fire protection: Inasmuch as fire protection was a function and duty of local county government, and as the commission did not regulate privately owned water utilities with regard to water supplies for fire protection, that portion of the water system required for providing fire protection could, in effect, be regulated by county ordinance.

Second, the applicability of a county ordinance to publicly owned water systems such as county water districts and irrigation districts was not clear. Subjecting these entities, formed in accordance with state law, to an ordinance would, in the opinion of some, be the same as regulating the state itself. This approach was based on decisions relating to the application of local building codes to construction of buildings by school districts.

Third, mutual water companies, the largest group of water utilities to be regulated, are subject to provisions of a county ordinance. To draft regulations for only one group, however, would be discriminatory.

Fourth, to further complicate the question of applicability, Assembly Bill 50391 [1] states, in part:

> . . . Building ordinances and zoning ordinances of a County or City shall not apply to the location or construction of facilities for the production, generation, storage, or transmission of water or electrical energy by a local agency.

The county counsel, however, has since ruled that the proposed water ordinance was not a building ordinance.

Zoning Ordinance Amendment

After the foregoing questions were considered, the idea was adopted that the ordinance provision should apply equally to all water utilities within the unincorporated territory of the county. To accomplish this, it was recommended that the zoning ordinance be amended to require, for authorization of zone changes or special permit for a use which would need a greater supply of water than the existing use, the receipt of a certificate from the applicant stating that such water could be supplied in accordance with the water ordinance.

A market being constructed in a residential neighborhood would require a special zoning permit, and, as a condition of the permit, the owner would be required to consult with the water purveyor for the area about the available water supply. If the existing water system was not adequate, this procedure would benefit both the owner and the water company, because they would be made aware of needed improvements and could work out together mutually equitable adjustments before construction was started.

A case in point is a recent action of the regional planning commission in granting a change of zone in Lancaster, Calif., from R-1, single-family residence, to R-4, multiple-family residence. This change resulted in the construction of several two-story multiapartment buildings. The water system operated by Los Angeles County Waterworks District 4 was not adequate in this area to furnish the additional water supply required; as a result the district, and therefore the inhabitants of the entire area, although they received no benefits from the improvements, paid the bill for the construction of adequate water facilities.

Other Amendments

It was also recommended that the building code be amended, as previously mentioned, to require that an applicant for a building permit furnish a certificate stating that water would be supplied to the proposed building in accordance with the terms of the water ordinance. A slight modification was recommended for the subdivision ordinance. This amendment required that, before the filing of a final map, plans and specifications for water supply should be submitted and approved by the county engineer.

Intent and Purpose of Ordinance

The intent of the ordinance seemed simple enough. The board of supervisors had ordered an ordinance regulating the installation of water mains and systems required for domestic, fire protection, industrial, and commercial supplies in subdivisions and new areas in unincorporated areas of the county. Varied terrain, including coastal plains, mountains, and deserts, together with highly varied population densities, made the application of uniform regulations difficult. Sparsely developed desert and mountain areas could not economically support the standards required for urban areas.

The creation of zones in which water requirements would vary according to

development would in effect set or influence insurance rates. Permitting the installation of substandard water systems to serve until areas developed did not seem to be the answer because it would result in duplication of work.

The standard of water quality for domestic purposes, and standards of construction required to provide such quality, were governed by the California Health and Safety Code and by General Order 103 of the California Public Utilities Commission. Public convenience, necessity, health, and safety required that reasonable fire protection be provided for new subdivisions, structures, and areas proposed to be rezoned for purposes requiring a greater supply of water for fire protection.

Sections 1 and 2 of the ordinance were written to clarify its purpose, intent, and applicability:

Sec. 1. *Purpose and Applicability.* The purpose of this ordinance is to promote and obtain a reasonable minimum level of fire protection performance for water supply facilities constructed, replaced, extended, or rehabilitated to serve new subdivisions and residential, commercial, and industrial improvements in the unincorporated area of the County of Los Angeles.

Sec. 2. *Intent.* The provisions of this ordinance are not intended to augment, supplant, or parallel any provisions of the Health and Safety Code of the State of California or order of the Public Utilities Commission pertaining to water supply, except as to fire protection.

Board of Appeals

In order to implement the operation of the water ordinance and adjust economic burdens and responsibility, an eight-member water appeals board was established. Membership on this board is by appointment of private citizens by the board of supervisors.

The members, by the terms of the ordinance, represent public utility management, fire protection engineering, builders-developers, mutual water companies, publicly owned water systems, the general public, organized labor, and engineering design. This board, with its wide scope of power, will adjust the application of ordinance provisions to eliminate economic hardship, hear disputes regarding proportionate share of costs to be borne by the builder and the water company, and recommend a solution. In addition, the board is empowered to rule on alternate materials of construction and make recommendations for amendments to the ordinance.

Specifications

Specifications and construction details are, in general, lengthy and subject to variation. An ordinance draft containing material specifications and construction standards would be lengthy and often not flexible enough for ease of administration. For these reasons, it was recommended that, in preparation of the draft, an ordinance be developed along the lines of "performance" rather than specifications, and that a separate "utility manual" be prepared to contain the necessary specifications to implement the performance requirements. The utility manual would be filed with the board of supervisors and amended from time to time as conditions warranted.

This recommendation was accepted and followed, resulting in a shortened ordinance. Section 252, pertaining to the utility manual, was included in the ordinance:

Sec. 252. *Utility Manual.* If the Engineer finds that, in order to comply with the provisions of this Ordinance, it is

necessary to conform to certain standards of materials or construction, or both, he shall promulgate such standards and publish the same in a Utility Manual. The Engineer shall file this Utility Manual and all amendments thereto with the Board. All construction and materials should conform to the Utility Manual described in this section.

Standards of material and construction, as published in the utility manual, will make extensive reference to AWWA standards and other nationally recognized standards.

Adoption of Ordinance

On Aug. 2, 1960, the Los Angeles County Board of Supervisors adopted the water ordinance as prepared by the county engineer and reviewed by the appointed citizens committee and other interested county departments. With the adoption, instructions were given that the section of the ordinance pertaining to the water appeals board be made effective on Sep. 2, 1960, and that the remainder be made effective on Jan. 1, 1961. This was to allow time for the water appeals board to become operative.

Although some objection remains as to the wording of the ordinance, particularly the parts pertaining to applicability (scope of ordinance), a spirit of cooperation is anticipated between the county, water utilities, and the water appeals board. It is believed that equitable solutions for hardship cases will be found, while a firm resolve is maintained to bring about an improvement in water systems in order that safe water in ample quantity can be delivered to the citizens of Los Angeles County.

Summary

The Los Angeles County Water Ordinance, as adopted on Aug. 2, 1960, is intended to:

1. Protect county citizens by providing regulations for the installation of water mains and water systems required for domestic, fire protection, industrial, and commercial supplies in subdivisions and new areas in unincorporated territory of the county
2. Aid the water supply industry by providing standardized design and construction requirements for water mains and related facilities
3. Give added fire protection by providing for the review of plans by the forester and fire warden in order to establish adequate fire flow requirements
4. Prevent unjust economic hardship of ordinance provision application by providing for the establishment of a water appeals board to resolve differences in interpretations and effect relief from unreasonable ordinance requirements
5. Assist in land development by providing regulations that will aid individuals and subdividers in constructing water systems in which financial institutions will have confidence
6. Share responsibility for administration and reduce red tape by providing methods that will permit the water utility industry to be as nearly self-regulating as possible
7. Insure adequate construction and material standards by providing that the county engineer may file with the board of supervisors a utility manual.

Reference

1. State of California Assembly Bill 50391, Statutes of 1959, Chap. 2110, p. 4908.

Ground Water Replenishment in Orange County, Calif.

Howard W. Crooke

A paper presented on Oct. 27, 1960, at the California Section Meeting, Long Beach, Calif., by Howard W. Crooke, Secy.-Mgr., Orange County Water Dist., Santa Ana, Calif.

IN the past 15 months, the Orange County (Calif.) Water District has purchased 200,000 acre-ft of water that has been brought 275 mi from the Colorado River into the district through the aqueduct system of the Metropolitan Water District of Southern California (MWD). This water has all been sunk underground to replenish the large ground water basin underlying the district. It cost the Orange County Water District, in round figures, $2,400,000, paid for by revenue derived from two sources. Approximately one-third was bought with money raised by an ad valorem tax on all real property within the district. Two-thirds was purchased with money collected from a replenishment assessment levied by the district on all water produced from the ground water supply and paid by those who pumped the water.

This large-scale replenishment program began in 1954 as a result of an act of the state legislature amending the Orange County Water District Act.

Replenishment Program History

The ground water replenishment program was not new to the district. When the Orange County Water District was created by the state legislature in 1933, it was charged with the responsibility of protecting and maintaining both the quantity and the quality of the underground water supply. The district comprises 190,000 acres, all of it within Orange County and overlying the coastal basin of the Santa Ana River drainage system, the largest watershed in Southern California. It is a semiarid region. The average annual rainfall in the watershed as a whole is 18 in., and in the district itself 13 in.

Fifty years ago, when Orange County had a population of only 25,000 and a very limited acreage in use for irrigated agriculture, the water supply was abundant. Artesian wells were flowing in many parts of the county. In Orange County, however, the pattern has been the same as in all other coastal Southern California communities. More and more people, industry, and commerce have been moving into the area, and the population in Orange County is now rapidly approaching the 1,000,000 mark. Throughout this period of unprecedented growth there has been a steadily increasing demand on the water supply. By some time in the 1920's, demand for water had reached a point where it was equal to the available annual local supply. Since that time, demand has continued to increase far beyond the point of equilibrium, making it necessary to

draw heavily on the ground water reserve of the district.

During the 10 years from 1941 to 1951, average water levels in the 3,500 pumping wells in the district dropped 38½ ft, and sea water had intruded into the basin as much as 4 mi on a 3- to 4-mi front (Fig. 1). In an effort to relieve this situation, the Orange County Water District in 1949 started buying Colorado River water to replenish the ground water supply. At that time the water was released from the main feeder line of the Colorado River Aqueduct where it crosses the Santa Ana River in Riverside County. From there it was allowed to flow downstream approximately 25 mi into Orange County to a 7-mi reach of the Santa Ana River bed maintained by the Orange County Water District as spreading grounds. In 1956 the MWD completed a new feeder line into Orange County, making it possible to take delivery of the water at a point only 3 mi above the spreading grounds in the river. The geology of Orange County is such that water spread in the sand and gravel of the forebay area, where the Santa Ana Canyon widens and joins the plains, sinks rapidly and mingles with the ground water supplies.

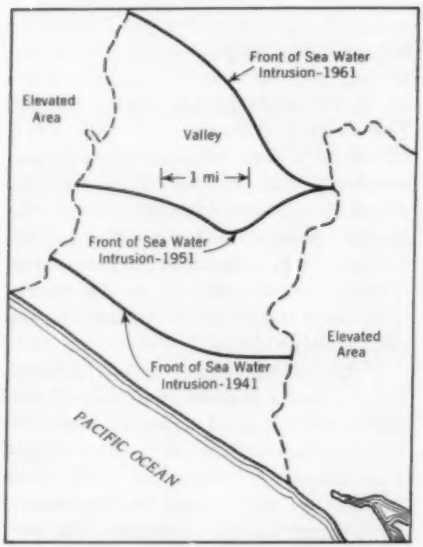

Fig. 1. Fronts of Sea Water Intrusion in Santa Ana Valley

Successive fronts of intrusion illustrate effects of dropping ground water levels.

The district obtained its funds for the first purchases of imported water in 1949 from an ad valorem tax on real property that was then restricted to a top limit of 15 cents per $100 of assessed value. The ad valorem tax, however, with the limited property values which prevailed at that time, did not provide enough money to buy imported water in the quantities needed to offset the overdrafts that were accruing annually on the district basin.

In the early 1950's, after 8 years of below-normal rainfall, with population and industry increasing beyond all expectations, the problem became acute, and county leaders turned their attention to finding ways and means of raising money on an equitable basis to pay for more Colorado River water.

Expanded Program

A committee of twelve men, representative of the various economic and geographic areas within the district, was named to formulate a sound, operational water management program that would provide adequate supplies of ground water for all the inhabitants and landowners of the district—present as well as future—and to do so by realistic financing shared on a proportional basis by those receiving either direct or indirect benefits. The plan the committee developed was to ex-

pand the basin recharge program under the authority of the Orange County Water District. It provided the necessary funds to purchase enough water to replace the annual overdrafts on the district basin and to raise water levels in wells high enough to stop further intrusion of sea water.

The recommendations of the committee were embodied in the amendments to the Orange County Water District Act that were adopted by the California legislature, signed by the governor, and made effective on Sep. 9, 1953.

1953 Amendments

The changes in the Orange County Water District Act were, in effect:

1. The district authority was extended to include Anaheim, Santa Ana, and a major portion of Fullerton (within the boundaries, but previously not part of the district); as well as Seal Beach and other areas along the west Orange County line. To provide adequate representation for all areas of the district, the board of directors was increased from seven members to ten.

2. The bonding provisions previously contained in the act were eliminated.

3. A new source of revenue was made available to the district, in addition to the ad valorem tax, in the form of a replenishment assessment on the production of ground water.

It was provided in the amendments that funds derived from the replenishment assessment—or "pump tax," as it is referred to locally—would be used exclusively for the purchase of imported water to replace the annual overdrafts on the ground water basin. The top limit on the ad valorem tax rate was reduced from 15 cents to 8 cents per $100 of assessed value, with funds from this source to be used to defray the administrative costs of the district and to buy enough water to replace, in a period 10–20 years, the long-time accumulated overdraft on the district basin.

When a replenishment assessment on water was first proposed, some said that it would take a five-story building to house all the employees needed. It is true that the collection of such an assessment had never been tried before. There was no handbook of easy instructions for the district to follow in putting the plan in operation, and each step had to be worked out, each problem resolved as it was encountered. Nevertheless, the district has successfully collected a replenishment assessment for more than 6 years—and with only twelve full-time employees. In addition to administering the program, these employees carry on all the other business of the district.

Program Operation

In operation, the replenishment program of the Orange County Water District consists of three major steps:

1. The district ascertains from an engineering investigation and report the probable overdraft on the district basin in the ensuing year. The act of 1953 spells out the specific information that must be contained in this report.

2. On the basis of the engineering report, the district levies an assessment to provide funds for the purchase of imported water. An ad valorem tax, necessary to meet the requirements of the general-fund budget adopted by the district, is levied by the county board of supervisors and apportioned on the county tax rolls affected.

3. The district buys water that originates outside the district, imports it to the spreading grounds, and adds it to

the ground supplies. To date, the only outside source is Colorado River water from the aqueduct system of MWD.

In the initial phase of the program it was necessary for all producing wells within the boundaries of the district to be registered and identified in the district office. It was also necessary to work out a procedure for the orderly registration of new wells and old wells put back in production. The amendments provide that it is the responsibility of the individual operator to register his wells with the district. They further provide that the initial registration of all producing wells at the time the program went into effect was to be completed by Jan. 15, 1954.

Annual Engineering Report

In March of each year, an engineering investigation and report concerning ground water conditions must be made to the board of directors of the district. After a public hearing on this report, it is considered by the board in determining the quantity of water to be purchased for the replenishment of the ground water supplies in the next year. The amount of money required to purchase this water at the prevailing cost and the estimated production rate for the next year provide the basis for the replenishment assessment rate. The board of directors levies the assessment on the second Wednesday in June each year and fixes the rate, after a public hearing on the need and desirability of levying the assessment.

Collection of Assessment

After the assessment has been levied, all the registered operators of water-producing facilities in the district are notified of the rate for the next fiscal year. Semiannually, in January and July, the operators are required to file statements on water production with the district, giving their production for the preceding 6 months. The assessment is based on the amount of water produced.

With the exception of the so-called "small wells," the owners of all water-producing facilities in the district are required to install and maintain on each facility a meter capable of registering the amount of water produced. The replenishment assessment is paid on the basis of meter readings.. If the water meter fails to register, then the records of past pump performance, hours of operation, and energy consumption are all useful factors in making a reasonable estimate of the production. It is the operator's responsibility to keep the meter in good repair so it registers correctly. The district has found it advisable, however, to employ a field man to make periodic readings of both water meters and electric-power meters. This information has proved to be helpful to the well owners as well as the district in administering the program.

The "small wells" referred to above are exempt from the metering requirements. Operators pay instead a fixed charge replenishment assessment annually in an amount equal to the prevailing replenishment assessment on 1 acre-ft of water. The wells in this category have a discharge outlet not greater than 2 in. in diameter and provide domestic and irrigation water for an area not exceeding 1 acre.

The replenishment assessment rate levied for the fiscal year 1954–55, the first year in which the assessment was levied, was $3.50/acre-ft of water produced.

In 1954, the board of directors filed an action in the Orange County Superior Court to establish the validity

of the amendments under which the replenishment assessment was levied, and to determine whether the proceedings of the board of directors in connection with the assessment were in proper order. The action was contested by two groups of respondents. The court found that the assessment levied by the board of directors of Orange County Water District was valid. This decision was upheld in the appellate court, and the supreme court of California denied a petition for rehearing the case.

In the second year of the program, the assessment was again levied at $3.50/acre-ft. In each of the next 3 years the rate was $3.90/acre-ft, and in 1959–60, owing largely to the increased cost of Colorado River water, the assessment rate was raised to $4.30/acre-ft of water produced.

In the first 6 years of operation of the program, the replenishment assessment collections totalled $4,100,000, all of which has been used to buy Colorado River water to sink underground. During this same period the ad valorem tax has been levied annually at the full 8-cent rate provided in the amendments, and all moneys from this source not needed for administration and operation of the district have also been used for the purchase of Colorado River water.

Water-Spreading Operations

To handle the large volumes of water being imported into Orange County Water District for replenishment of ground water supplies, the district owns approximately 800 acres of land for use as spreading grounds. The largest area is the 725 acres in the Santa Ana River channel, which overlies the recharge portion of the district basin. The district tries to maintain the spreading grounds in the river bed in such a way as to obtain the greatest possible amount of percolation from both the natural flow of water from upstream and the Colorado River water that is discharged into the river.

The facilities in the Santa Ana River are being supplemented by spreading sites outside the river channel. One of these consists of 25 acres, portions of which have been excavated to a depth of 20 ft, and is currently in use for sinking water. The other, a 65-acre site, was excavated to a depth of 50 ft, and part of it will be ready for use in 1961. The MWD is building a feeder line to this 65-acre site which will deliver water at the rate of 300 cfs directly into the pit. This feeder line is also scheduled for completion during 1961. With these additional facilities for water delivery and spreading, it will be possible for the district to receive and sink larger volumes of water underground. In addition, a large portion of the water can be received during the winter months, when the demands for MWD water are the lowest. The river bed will then have a chance to dry out during the summer months and will be in better condition to absorb a larger percentage of the winter and spring runoff.

Orange County Water District is currently carrying on experimental water spreading in cooperation with other agencies in other areas of the district to determine where other sites can be developed for spreading water with beneficial results.

Maintenance of Water Levels

Because of the replenishment program, the steady decline in water levels in the district basin has been halted. In contrast to the drop in water levels

that occurred year after year before the program started, a ground water contour map as of Nov. 1, 1960 (Fig. 2), shows water levels to be, on the average, higher than they were in 1956 (Fig. 3), two years after the expanded replenishment program was begun. In the past 15 months, the district has spread 200,000 acre-ft of Colorado River water, and water levels in the district basin about one-third of the way to the coast have risen dramatically. In the upper portion of the pressure area, the rise in water levels has also been substantial. Nearer the coast, however, well measurements indicate no appreciable change. Were the district to be blessed with a wet winter, which would relieve the pumping draft, the district's engineers think that the results of the ground water replenishment program would be evident throughout the district basin.

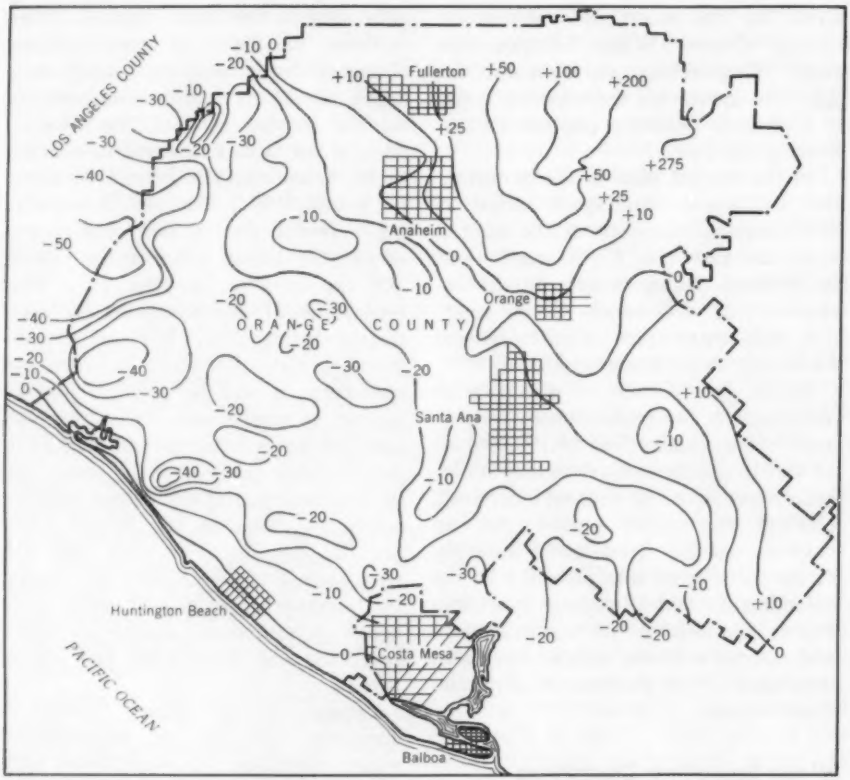

Fig. 2. Orange County Ground Water Levels in 1960

Contour designations indicate feet above or below sea level.

Need for More Water

With the completion in 1960 of its $200,000,000 expansion program, MWD has enough capacity in the

aqueduct system to transport into Southern California its entire annual contract allotment of 1,212,000 acre-ft of Colorado River water. Although Orange County Water District can, for the time being, get as much Colorado River water as it has money to buy, indicate its ultimate allocation of MWD water may be. Orange County at this time is receiving water not needed by other member agencies of MWD. When those agencies need all the water they are entitled to, Orange County's allocation will be cut back to

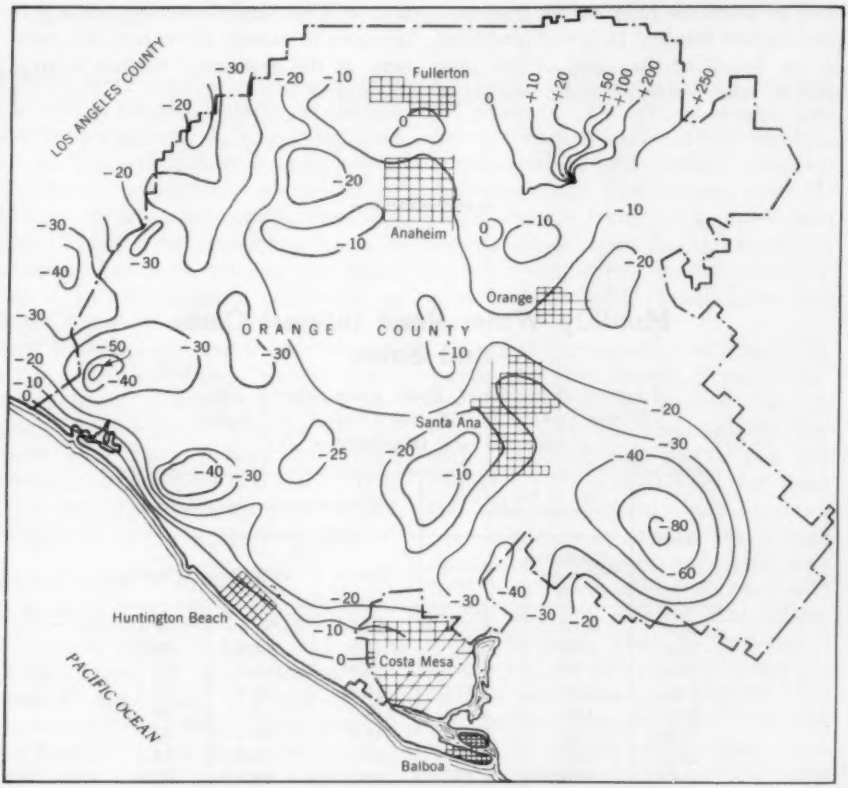

Fig. 3. Orange County Ground Water Levels in 1956

Levels are somewhat lower than those of 1960, reflecting effectiveness of replenishment program despite continued heavy use of ground water.

no one knows how long this will be true.

According to Harvey Banks, state director of water resources, Orange County last year received approximately 2½ times what present trends a proportionate share. This will probably occur during a period when, according to estimates by the State Department of Water Resources and others, the need for imported water in Orange County will have doubled.

In 1960, the seventh year of operation of the ground water replenishment program, the board of directors of Orange County Water District levied a replenishment assessment at the rate of $5.50/acre-ft of water. This was a substantial increase over the $4.30 rate for 1959 and should make it possible to purchase more water from replenishment funds. It is the intention of the board of directors of the district to take whatever additional steps are necessary to provide adequate revenues to buy as much Colorado River water as possible during the next few years. If the ground water basin is filled to the highest practical level while Colorado River water is still available, the land owners and inhabitants of the Orange County Water District will be assured an adequate supply of water to sustain the expanding economy of the area until further sources are found.

Monthly Water Bond Interest Costs and Sales

A report of the Chief, Basic Data Branch, Div. of Water Supply & Pollution Control, US Public Health Service, Washington, D.C.

Month	1960–61 Net Interest Cost—*per cent*		Total Bond Sales—*$1,000,000*		
	General Obligation Bonds	Revenue Bonds	1960–61	1959–60	1958–59
Mar.	4.12	5.00	19.5	57.0	24.8
Apr.	3.95	4.49	38.2	44.4	40.0
May	3.79	4.29	49.9	105.5	22.7
Jun.	3.77	3.77	11.4	50.3	20.1
Jul.	3.99	3.93	133.1	17.3	39.0
Aug.	3.34	4.02	48.4	25.5	37.7
Sep.	3.82	3.75	18.8	16.6	14.3
Oct.	3.64	3.85	21.0	68.4	60.8
Nov.	3.36	3.86	18.4	36.3	42.5
Dec.	3.55	4.20	77.3	18.4	11.5
Jan.	3.88	3.70	37.8	21.2	28.3
Feb.	3.41	3.71	19.4	41.7	62.1
Total			493.3	502.6	403.8

Industry's Concern With Off-the-Job Safety

—S. M. Hoffman—

A contribution to the Journal by S. M. Hoffman, Safety Consultant, Management Consulting Div., Ebasco Services Inc., New York, N.Y.

THE large number of persons hurt and killed each year in off-the-job accidents imposes a staggering loss on society and industry. Employees, managers, taxpayers, and people in general share in the financial loss and bear the emotional consequences. The problem has been present for some time. It will probably get worse as fewer hours of work are required to earn a living. As people have demonstrated their inability to protect themselves against accidents, a formal program designed and administered by those with the necessary knowledge and experience seems necessary. It is high time to examine the problem and establish a formal program of defense.

Examination of Problem

First the problem must be examined. For many years industry has been doing a good job in preventing accidents to employees. Because of this concerted effort, today fewer persons are hurt and killed than formerly, and less money and property are lost. Today, however, industry is paying a fantastic sum for accidents that happen to employees off the job. So far, industry is doing very little to reduce this cost. Accidents involving members of employee families also contribute to this cost.

As with the cost of accidents in industry, there are both direct and indirect costs involved in off-the-job accidents. The direct costs include the payment of unearned wages, employee benefits, and certain medical, hospitalization, and welfare program disbursements. The indirect costs include absence from work, production losses, and mistakes on the job arising from an employee's mental condition when members of his family have been hurt.

Perhaps one reason that greater effort has not been devoted to reduce off-the-job accidents is the belief that the employer has no responsibility for them. Although this may be true, the employer pays a high price for these accidents regardless of who is involved.

Industrial management has a high regard for employees and their welfare; it is also deeply concerned with profits and any element that affects the profit rate. Thus the problem of off-the-job accidents as a factor in efficient operations is of interest from a corporate viewpoint. Basically, the control of off-the-job accidents is a simple problem. It is also a big one. A few concerns have been working on this problem for some time, but for the most part, companies make no formal effort to control such accidents.

Estimate of Accidents

The annual estimate of off-the-job accidents is 29,200 fatalities, 2,300,000 disabling injuries, and 5,000,000 non-

disabling injuries. Total man-days lost are 50,000,000. The total economic loss amounts to 3.5 billion dollars, and the loss to employers alone is about $500,000,000. Of the 29,200 killed, 17,000 lose their lives in traffic accidents; 6,400 suffer fatal public accidents, and the remaining 5,800 meet death through accidents in their own homes. Of the disabling injuries, 600,000 result from traffic accidents; 800,000 from public accidents; and 900,000 from home accidents. More than 20 per cent of these victims are industrial workers.

The estimate shows further that deaths per 100,000 workers occur at the rate of 49 off-the-job to 22 on-the-job, a ratio higher than 2 to 1; disabling injuries per 1,000 workers occur at the rate of about 40 off-the-job to 30 on-the-job; a ratio of 4 to 3.

Figures compiled by various companies tell an even more dramatic story. In some cases off-the-job disabling injuries occur 20 to 40 times as often as on-the-job injuries. Although some companies have outstanding records with no disabling injuries at work over long periods of time, their employees go right on suffering disabling injuries off-the-job.

Almost 200 companies that maintain formal safety programs have found that on-the-job training helps prevent and control off-the-job accidents. In a recent year the 1,100,000 employees of these companies lost a total of 651,700 man-days and suffered a total of 194 fatalities in off-the-job mishaps. The average frequency rate was 8.6 injuries per 1,000,000 man-hr off the job, calculated at 72 hr per week exposure. The average severity was 158. Both these rates are considerably lower than the rates of companies that do not have safety programs.

Addressing the Greater New York Safety Convention earlier this year, Arthur S. Johnson, vice president of the Mutual Liability Insurance Company, predicted, "Accidental deaths in the home will soar nearly 80 per cent in the next 10 years, unless the family unit learns to manage itself safely."

Application of Employee Safety Programs

In view of the off-the-job accident situation as it exists today, and considering the trends that have been established, it is a matter of simple arithmetic to foresee that measures of control are needed. It seems logical that the best way to improve the situation and establish some control is for people to learn that preventing accidents is a matter of family willingness, knowledge, and ability to organize for their own defense.

With the funds and leadership supplied by executive management, safety men in industry are doing a good accident control job. Many concerns have organized, partially organized, or participated in community safety projects; companies generally have the experience and facilities to establish and promote accident prevention programs that would apply to all members of the family as well as the employee himself. Experience gained in preventing accidents in the plant has a definite application to off-the-job accident control, and because industry cannot escape the burden of these accidents, the matter should be of extreme interest to management.

If a program for off-the-job safety is adopted, high ranking executives must again take the lead and demonstrate their sincerity and determination by laying out a definite program and taking part in the activities. Since

such a plan would take the company closer to the employee's home, workers must thoroughly understand the reasons for the company's interest. Invading a worker's home, even with a plan as honorable as the desire to keep people from being hurt or killed, can backfire. Thus attempts to compel employees are neither practical nor desirable. It is important, however, to recognize that employees can be influenced in their off-the-job thoughts and actions by on-the-job leadership and guidance.

Causes of Off-Duty Accidents

Of course, an important element of any such program is a knowledge of the way in which accidents occur off the job and an understanding of the total problem. Planners must know, for example, that most traffic accidents, which account for the larger number of deaths, occur when motor vehicles collide with each other, strike pedestrians, overturn, or run off the road.

The three chief causes of death from nontransport public accidents are drowning, falls, and firearms. Most sport and recreational deaths fall into this category. Transport deaths are those involving transportation other than motor vehicles; the largest number of these is associated with water. The nature of this hazard is indicated by the fact that 75 per cent of the water transport drownings involve boats designed for less than 10 persons.

As in industry, falls are high on the list as a cause of death in the home. Burns and other injuries from fires frequently cause death in home accidents. Amazing as it may seem, over 80 per cent of the accidental poisoning cases, and almost 50 per cent of all fatal firearm accidents, occur in the home.

Safety Principles

The factors that keep employees safer on the job than at home are readily determined. The employee is kept safe at work because of the sound principles of accident prevention that have been developed and are integrated with all aspects of his job. For example, every effort is made to

1. Match the mental and physical characteristics of the employee with the job
2. Instruct, supervise, and motivate the employee to do his work the safe way
3. Provide tools, work area protection, machine guarding, and protective equipment as required to do the work safely
4. Establish standards of safe procedures and a company policy that assures a high regard for the safety of all employees.

Reasons for Off-Duty Hazards

These principles form a network of safety, guiding and controlling the actions of workers on the job. Unfortunately, they are usually left behind when the employee checks out at the end of the shift. At this point the worker enters the general public. Without the network of safety provided on the job he faces the hazards common to the general public on the streets and highways, during recreation, and at home. He is now beyond the observation of his supervisor and the organized help of his fellow employees. Under these conditions any formal interest he has in preventing accidents to himself and his family will depend on his ability to translate the provisions of his company's safety program into measures that will provide personal and family protection.

While at work, a man uses the experience and judgment of his supervisor. Moreover, he has learned not to attempt a job for which he is inexperienced without special instructions. But at home, without hesitation, he will use high speed tools, power machinery, high ladders, and other devices that he is not trained to use. He is thus unable to foresee and cope with their particular hazards. Although he knows that both safety and efficiency suffer when weak and defective equipment is used, he will jeopardize his life and the future of his family by not taking time to make inspections and repairs.

Perhaps it is not fair to charge the employee with complete disregard for safety in connection with some of his home activities. Besides being inexperienced with some equipment and devices, it may well be that he just doesn't know the safe way. On the other hand, the matter of plain economics may be the major reason why he engages in off-the-job activities for which he is unsuited both mentally and physically. Recognizing this situation as part of the problem, the need for programing to prevent off-the-job accidents becomes even more compelling.

Concern of Industry

The harmful effects of off-the-job accidents on industry, the nation, and the employee himself are numerous. Absenteeism is one of the obvious results, and a problem that industry must cope with because it leads to higher costs of production and the loss of experienced and skilled manpower. The employee and his community are often affected economically, and there may be financial hardship for the employee if sustained disability or permanent impairment results. While partially disabled, employees often return to light work or a regularly established job within their physical capacity. Thus a substantial sum may be lost in wages for time which is either nonproductive or below the established standards of production. Admittedly, an early return to work may have some therapeutic value and in some measure lessen the need for a temporary replacement. It may also tend to lower the cost in wages or benefits that would be paid in case of complete absence. Furthermore, it is possible that an early return to work will lessen the more subtle consequences, such as mental anguish, that are frequently as responsible as physical pain or impairment for reducing efficiency and production.

Emotional balance is essential to efficiency and mental alertness. Worry about home conditions and anxiety for the future can quickly lead to an alarming neglect of responsibility and a drop in safety and efficiency. It is certain that an off-the-job accident to a member of a family can be the direct cause of an employee's on-the-job injury.

Accidents that occur on the job are a matter of company knowledge, and sustained absence usually results in an investigation of home conditions to determine whether financial assistance is needed. Although less likely, an investigation and follow-up may also be made when an employee is absent because someone at home has been injured. These cases are a very personal matter to employees and may have far-reaching effects. The family member who is an accident victim may be responsible for the employee's emotional disturbance and inability to meet his personal responsibilities. Furthermore,

if the employee's resources are entirely depleted and he has to apply for public assistance, he becomes an economic liability to his community. He may also become a poor representative of his company, both by his words and actions. The possibility of this situation is increased if he is in the clutches of a loan shark.

The financial contributions by industry for the support of community hospitals, welfare organizations, and public services, though helpful, may not prevent these services from being overburdened and understaffed. If employees hurt in off-the-job accidents, people injured on streets and highways, family members hurt falling down basement stairs or hurt while cleaning or cooking, and children poisoned from bottles left within their reach did not need public assistance, then the need for community contributions would be substantially reduced.

No one wants to see his friends and employees suffer. This is industry's humanitarian interest in the problem. The humane factors are sufficient to warrant participation in off-the-job accident programs, but there are other reasons that make good business sense.

The above-mentioned losses from off-the-job accidents readily indicate the possible financial return from an off-the-job safety program. Thus the expense of operating such a program can be justified simply by the fact that a company is run to make a profit. Management is always interested in ways to increase profits. Then too, an off-the-job safety program contributes to good public relations. It reflects interest in people and employees beyond the usual company-employee-community relationship; it can be used to reflect industry's concern with the welfare of society and the nation.

Programs in Effect

Some companies that foresaw the benefits of off-the-job accident control have instituted formal programs. The scope of these programs varies in depth and intensity, but some concerns are making a concentrated effort to reach the family and the whole community of their employees.

In 1943, the du Pont de Nemours Co. applied research to the problem and found that at least four times as many employees of the company were injured off the job as were injured at work. It found that these off-the-job injuries, in addition to causing pain and suffering, upset the normal home lives of their employees and constituted an appreciable economic loss.

Replacement of injured employees and their assignment to light and restricted work often presented problems to supervision. Furthermore, lower individual efficiency usually resulted. Then too, with the company bearing the cost of hospital and surgical insurance, group life insurance, and the disability wage plan, off-the-job injuries added to operating costs.

In 1955, a du Pont executive said, "The management of du Pont ranks safety in importance along with cost, quality, and the other factors which determine if a business is to be profitable. Safety is in no sense a fringe item but is considered a regular part of each employee's assignment, whatever it may be. Doesn't it make good sense for every one of us to borrow from industry's approach and make safety an essential part of our home operations and away-from-work activity?"

Du Pont now has a comprehensive off-the-job safety program built around four elements:

1. *Everybody needs it.*

Families need it because injuries are the greatest source of death among children.

Young people and adults who drive cars need it because vehicles are the most destructive pieces of equipment in the hands of the public today.

Parents need it so they can set a good example for their children.

Those who enjoy taking vacation trips, and those who enjoy sports, need it because injuries can interrupt their plans and keep them from having fun.

Elderly people need it because they are more subject to crippling injuries from falls. Such injuries make them a burden to those who care for them.

2. *People are safer on the job than off the job.*

Many industrial employees work for firms that encourage them to work safely.

While employees apply some of their safety knowledge off the job, it is plainly not enough. Annually almost 2.5 million injuries and deaths result to workers while they are away from work.

Injuries occur frequently at home, from public activities such as sports, and from motor vehicle accidents. The greatest proportion of deaths occur from motor vehicle accidents.

3. *Off-the-job safety needs to be an integral part of industry's on-the-job safety program.*

Industy has been successful in reducing on-the-job injuries. The knowledge gained in accomplishing this should logically be applied to providing off-the-job safety.

Several motives encourage industry to provide direct assistance to off-the-job safety: the wish to improve public relations, to reduce operating costs, to contribute to the security of employees, to enhance the welfare of the community, or to improve on-the-job injury experience. These are some of the major motives. Whatever the reason, the daily accident toll throughout the country on highways, at play, and at home is becoming so large that industry must inevitably accept its share of the responsibility for preventive action. Such action is obviously humanitarian, but it is also sensible and economical.

There need be no feeling of paternalism in industry's accepting the vital role that it must play in the prevention of off-the-job injuries, for this activity demonstrates its belief in the dignity and worth of each individual.

4. *Off-the-job safety is beneficial to all.*

Off-the-job injuries are a significant part of our national economy. The cost of manufacturing goods is increased when workers get hurt, whether on or off the job. Some of the items affecting operating costs are: (1) The need for relief personnel, and training for such personnel; (2) Product spoilage or damaged equipment that may accompany the work of newly trained employees; (3) Additional work loads placed on supervision; (4) Injured employees not able to do their full share of work upon returning to their jobs; (5) The increase in payments for accident and health insurance, hospital and surgical insurance, and group life insurance; (6) The additional cost for disability wages.

When off-the-job injuries occur, a host of community services and facilities may be called into action: hospitals, rehabilitation centers, orphanages, and welfare agencies. These community services and facilities are already overcrowded and their ability

to render service overtaxed. They are generally supported by tax dollars or by contributions; everyone is involved.

"Safety is not something that can be put on when a person goes to work and removed when he leaves for home," the du Pont Company said. "The emphasis on nonwork injuries apparently creates a favorable state of mind which carries over into an individual's safety performance on the job. When he has the habit of driving safely, walking safely, and doing jobs about the home in a safe manner, it is that much easier for him to follow a similar habit on the job."

Continuing, the company stated, "Prior to launching the company-wide effort to get safety applied off the job, it was anticipated there might be some feeling the company was encroaching on an individual's 'freedom of action.' However, this feeling has not materialized. The employees have accepted the philosophy that off-plant injuries are preventable and that efforts should be made to prevent them. The program has assisted employees to carry safety home to the members of their families in a more effective manner, and many ideas have been used to obtain family participation and interest in the program."

Company Objectives

The American Telephone and Telegraph Co. is another on the growing list of concerns participating in off-the-job accident control.

In the company it was found that disabling injuries to employees away from the job outnumbered those occurring on the job by as much as 40 to 1. A 10-year study revealed that off-duty fatalities averaged 166 a year, compared to an average of 12 per year on the job.

The company stated, "We are paying a tremendous price for injuries sustained by telephone company employees while off the job, in the homes, in public places, and on streets and highways. Off-duty accidents are not only the concern of employer and employee, they also concern the family and the entire community. The cost and suffering caused by accidents affect everyone. Many of the costs of off-duty accidents are just as great to the company as if they had occurred while the employee was on the job. The suffering and mental anguish of the employee and his family are the same."

Here are a few of the costs found by the companies:

1. Loss of production because of absence
2. Unearned salaries paid
3. Wages in full paid after the injured employee returns to duty until he is again fully productive
4. Cost of time in selecting and training a new employee to replace the injured or absent employee
5. Loss of work force efficiency.

AT&T believes that off-duty accidents can be prevented. It says this has been demonstrated by the progress made in several operating companies and many outside industries.

It believes the primary requirement of any accident prevention program is a good fact-gathering routine. "This," it says, "will keep us informed on the magnitude of the problem and progress being made. We will then have an indication of where and how to focus our attention to bring about more improvement. Management at all levels must, of course, take the lead and show their sincerity and determination in accident prevention around the clock by laying out a definite pro-

gram and taking an active part in the measures planned."

There is no better way to demonstrate a genuine interest in public relations, community living, and cost control than by reducing absenteeism caused by needless accidents.

At AT&T's Operating Vice President's conference in 1956, a method for reporting off-duty injuries was developed. Subsequently a program for improving off-the-job safety was established. In introducing the program to the system companies two primary purposes were outlined:

1. To prevent pain, mental anguish, and financial losses to employees and their families.
2. To reduce absenteeism and other related effects of preventable off-duty accidents.

In developing their program, the company concluded that to convince employees of their interest, both the total time lost and the lost-time accidents should be classified. "In reporting total days lost," the company said, "we are aware of the true severity of the injury, rather than company loss only."

In submitting the off-duty accident program, it was recommended that competition not be used, as it would have a tendency to hinder rather than help a plan of this type. It was also pointed out that as the program depends on employee acceptance, it would be more successful if voluntary participation were achieved.

Conclusion

This briefly outlines some of the reasons for an off-the-job safety effort and describes the program of two major companies. Many other concerns have programs, but in general, the effort to improve the off-plant accident situation in no way matches the problem, nor is it consistent with the needs.

The problem is indeed challenging; the benefits, both humanitarian and financial, are great.

Accounting for Water in Wisconsin

William A. Kuehlthau

A paper presented on Sep. 29, 1960, at the Wisconsin Section Meeting, Madison, Wis., by William A. Kuehlthau, Engr., State Public Service Commission, Madison, Wis.

WHEN a community faces a water shortage, it usually increases its source of supply. This ordinarily calls for enlarging the treatment and pumping plant facilities and the transmission main system. Some communities, however, may eliminate a shortage by more efficient or more complete use of the existing supply. To do this, the community must know what proportions of the existing supply are going to the various uses.

Metering the water used by the various consumers will give this information. Whenever practical, the water for all users and uses must be metered. The installation and reading of meters does not do the job adequately and accurately. The accuracy of the meters must also be maintained.

In the early days of Wisconsin water utilities, metering was not given as much attention as it has today. The water use per customer was low. "Added cost," as it might be termed, was small in comparison with the other costs involved. A practical source of supply was much larger than required to meet the immediate demands as well as the growth anticipated for a number of years. Many utilities found their initial well was an adequate supply for 20 years and more. There was plenty of water, and waste was tolerated.

The situation has changed. Industrial growth and the changing way of living have greatly increased the amount of water used, making it necessary to eliminate waste. An initial step is the installation of meters for all customers. A second step is to provide proper meter maintenance.

Improvement in Wisconsin

Records of Wisconsin utilities show the improvement that has been made. Of the seventeen largest water utilities in the state in 1959, only two reported unmetered customers, and these totaled 31. In 1931, the same seventeen utilities reported a total of 8,592 unmetered customers. Among all these utilities, this was only 3.6 per cent of the customers, but it amounted to 67 per cent of the customers of one utility and 35 per cent of another's.

Metering service is of primary importance because it provides a basis for definite and fair billing. It is important also because it deters waste on the part of the customers. Records of pumpage by utilities that did not meter service show a definite reduction after meters were installed and metered rates applied. Although installation of meters for all customers is of prime importance, the meters must also be accurate when installed and maintained for continued accuracy until they are retired.

It is not strictly true that metering all services will tell the utility how much water its customers are using,

TABLE 1

Metered Sales—Proportion of Total Water Pumped

Utility	1959 Pumpage *1,000 gal*	Customers in 1959		Metered Sales—Percentage of Total Pumpage			
		Metered	Unmetered	1959	1958	1957	1956
Algoma	87,369	1,066		93.5	93.3	90.5	91.7
Appleton	2,086,781	13,023		75.3	74.0	78.0	77.2
Ashland	383,607	2,792	547	58.3	51.6	53.5	57.1
Barron	1,534,183	763		78.9	78.2	77.4	60.2
Beaver Dam	405,709	4,184		79.8	83.3	83.7	82.4
Black River Falls	122,438	984		63.4	76.1	74.5	80.7
Brodhead	63,733	585		51.5	48.6	44.5	55.0
Cedarburg	289,455	1,330		96.5	94.4	95.1	97.0
Clintonville	184,525	1,535		72.5	65.3	63.2	67.7
Columbus	106,738	1,171		70.6	72.2	95.2	
Cumberland	159,833	503	62	85.2	81.1	76.3	72.0
Eau Claire	3,408,610	10,003	21	87.7	93.2	98.2	87.9
Elkhorn	118,360	1,163		86.6	72.9	79.9	79.3
Evansville	93,196	998		73.6	80.7	60.1	72.5
Fond du Lac	1,148,081	9,611	10	84.8	76.7	73.7	74.3
Green Bay	2,839,758	16,179		91.5	91.7	90.7	88.3
Hartford	400,534	1,509		56.7	78.3	86.3	78.0
Janesville	2,267,797	10,137		76.9	72.5	75.1	66.7
Jefferson	280,696	1,335		76.7	78.1	75.1	80.3
Kaukauna	273,935	2,517		76.9	86.3	90.5	95.1
Kenosha	3,795,629	16,838		86.3	82.3	83.0	85.1
Kiel	46,475	696		92.5	93.9	95.4	73.7
Lake Mills	177,832	1,078		65.0	50.3	59.4	63.3
La Crosse	3,068,469	12,240		98.6	85.2	88.7	101.1
Madison	6,434,358	26,750		92.7	87.9	90.0	90.1
Manitowoc	1,984,019	8,104		87.5	85.5	88.0	87.4
Marinette	815,433	3,340	568	38.9	30.9	65.2	63.3
Marshfield	550,665	3,475		80.0	79.0	85.7	86.5
Menasha	1,432,856	3,788		88.4	85.4	88.7	88.8
Milwaukee	51,903,458	143,583		88.2	89.2	90.2	88.2
Neenah	607,500	5,090		74.6	73.8	76.2	79.8
New London	221,130	1,700		88.6	80.5	79.3	69.2
New Richmond	155,266	998		86.3	94.3	73.9	79.8
Oconomowoc	243,838	1,989		97.5	99.2	90.8	91.2
Oshkosh	1,600,881	11,904		81.3	82.1	82.5	75.6
Plymouth	266,938	1,521		84.9	80.4	77.4	83.4
Port Washington	245,345	1,631		69.1	74.9	70.0	72.0
Racine	5,058,050	22,487		87.5	88.2	86.2	85.0
Reedsburg	134,233	1,422		85.9	87.0	72.9	81.4
Rice Lake	287,319	2,063	18	70.4	71.4	71.9	67.3
Richland Center	194,823	1,696		85.0	78.7	76.7	60.4
River Falls	186,843	1,158	61	65.2	66.1	68.4	70.3
Shawano	361,604	2,068		91.4	89.4	91.4	86.6
Sheboygan	3,150,755	12,127		85.5	87.1	88.2	90.8
Sheboygan Falls	162,861	1,225		90.0	96.9	90.2	85.3
Shorewood	634,134	3,595		87.4	90.9	80.4	80.7
South Milwaukee	1,079,843	4,383		89.2	90.2	97.3	94.8
Stevens Point	752,032	4,703		83.5	79.4	83.4	82.1

TABLE 1—*Metered Sales—Proportion of Total Water Pumped (Contd.)*

Utility	1959 Pumpage *1,000 gal*	Customers in 1959		Metered Sales—Percentage of Total Pumpage			
		Metered	Unmetered	1959	1958	1957	1956
Sturgeon Bay	412,003	1,990		53.1	51.2	51.9	45.0
Two Rivers	609,388	3,253		88.6	80.3	87.3	85.8
Waterloo	81,779	730		83.5	95.7	92.8	91.0
Watertown	498,774	4,168		74.9	83.3	87.6	92.2
Waukesha	1,433,806	6,737		89.0	90.7	89.6	93.2
Waupun	184,507	2,163		71.6	78.8	83.3	82.2
Wausau	1,396,280	9,145		82.3	84.9	83.0	75.8
Wauwatosa	1,461,623	10,287		87.3	80.0	84.5	83.7
West Allis	2,684,846	13,762		89.9	94.6		86.7
Wisconsin Rapids	1,161,450	4,063		81.4	83.7	84.7	84.4
Lake Sup. Dist. Power Co.	30,617	315		60.0	47.7	55.1	52.1
Sup. W. L. & Pr. Co.	1,322,590	9,126		68.8	69.0	67.4	68.5
Wis. Pr. & Lt. Co.	1,954,218	12,374		74.1	72.3	77.4	74.9

as even new water meters do not register all rates of flow with complete accuracy. If the meter registers all of the flow at the middle and upper ranges of flow, it will underregister at low flows. The meter is not capable of low-flow adjustment comparable to the low-load adjustment of an electric kilowatt-hour meter. As a result, even with meters in the best of adjustment, with no unmetered use, and with no leaks in the system, the total of the consumers' meter readings will not equal the amount of water pumped into the distribution system. After meters have been installed for some time, the difference is larger, because water meters slow down with use or age, and rarely if ever gain.

Meter Effectiveness

Table 1, made from annual reports of all Class A and B utilities, shows the total gallons of water pumped to the distribution systems, the number of customers in 1959, and the metered sales for 1956–1959 as a percentage of the water pumped. In Fig. 1, these percentages have been plotted against the number of customers. Although the points are fairly concentrated, there appears to be no regular pattern. Three utilities, Cedarburg, La Crosse, and Oconomowoc, report very high percentages of over 96 per cent, but it is not known if special circumstances account for them.

From the experience of 17 large utilities during the 29-year period 1931–1959, it has been observed that most utilities increased the percentage of water registered. There are a few exceptions. Kenosha, for instance, went from 69.3 per cent in 1931 to 94.5 per cent in 1944, and down to 82.3 per cent in 1958. Janesville has a similar record. West Allis shows a rather erratic variation and reported 107 per cent in 1943. Obviously, this is not correct. Oshkosh and Eau Claire are also erratic. Again, the reasons for these peculiarities are not known.

Unmetered Water

From a survey of these figures, the author judges that a utility registering

90 per cent of its water is doing an excellent job. Where does the rest of the water go? There are several unmetered uses: for street and sewer flushing, fire fighting, flooding skating rinks, filling swimming pools, operating drinking fountains, and many others. Some of these uses can be estimated with a reasonable degree of accuracy, but others, such as sewer flushing, fire fighting, and flooding skating rinks, present a more difficult measurement or estimating problem. Many utilities, however, do make a serious attempt to account for the known uses of water that are impractical to meter. Because the annual reports do not provide for estimated amounts of unmetered uses of water, utility experience in this matter can not be reported here.

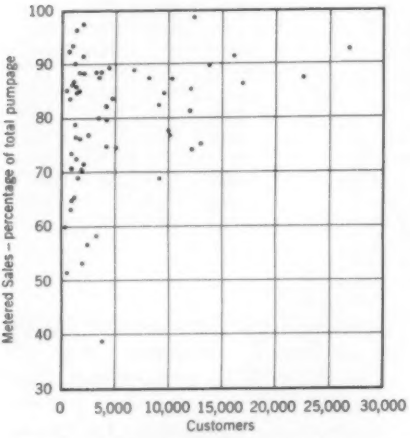

Fig. 1. Metered Sales—Percentage of Total Pumpage and Number of Customers per Utility

Dots represent 1959 reports of Wisconsin Class A and B utilities.

The known unmetered uses account for part of the unmetered water, leaving the remainder to be attributed to inaccurate meter registration and leaks in the utility's system of mains. Are leaks an appreciable item? What, for example, does a main break like that in Milwaukee on Sep. 15, 1960, amount to in terms of annual pumpage? Milwaukee probably has several main breaks each year, probably not as spectacular as this one, but all together, are they half of this 10 per cent? What are the estimates on the amount of water lost through leaks that are too small to show on the surface?

A few utilities report metering over 100 per cent of the water pumped. One reason for this might be underregistration by the master station meters. What is the practice in testing these meters? Are they tested periodically? How well do they maintain their accuracy? This applies as well to customer meters of 2 in. and larger, which are beyond the capacity of test equipment of many utilities.

Government Functions in Pollution Control

Joint Discussion

A joint discussion presented on Mar. 23, 1961, at the Illinois Section Meeting, Chicago, Ill.

Federal Activities—*Gordon E. McCallum*

A paper presented by Gordon E. McCallum, Chief, Div. of Water Supply & Pollution Control, USPHS, Washington, D.C.

THE laws and authority under which federal government agencies operate sometimes become obscure to the general public. Even those who administer the laws occasionally seek legal interpretation. This article, therefore, discusses one function of the government, its work to control water pollution. Federal pollution control work in Illinois will be particularly considered.

When the present Federal Water Pollution Control Act—Public Law 660—was passed by Congress in 1956, it was heralded as a forward looking piece of legislation. As early as 1900 Congress recognized that the character of the problem was becoming national. But not until 1948 did it pass the first federal legislation dealing comprehensively with water pollution. The 1956 act, under which federal agencies now operate, was an extensive amendment to that of 1948. The water pollution control program is administered by the surgeon general under the supervision and direction of the secretary of health, education, and welfare.

Now nearly five years have passed under Public Law 660. It is a good time to assess the accomplishments, to face up to new needs that have cropped up, and to determine future courses of action.

Public Attention

In recent months, public attention has been sharply focused on water pollution and what it means in the citizen's everyday life. First the National Conference on Water Pollution called attention to pollution. Then the final report to Congress by the Senate Select Committee on National Water Resources after 2 years of nationwide hearings and intensive study of water problems reported its findings, and then the President spotlighted the problem.

On Feb. 23, 1961, in a message to Congress on natural resources, President Kennedy said:

> Our nation has been blessed with a bountiful supply of water, but it is not a blessing we can regard with complacency. We now use over 300 bgd, much of it wastefully. By 1980 we will need 600 bgd . . .
>
> Pollution of our country's rivers and streams has—as a result of our rapid population and industrial growth and change—reached alarming proportions. To meet all needs—domestic, agricultural, industrial, recreational—we shall have to use and reuse the same water,

maintaining quality as well as quantity. In many areas we need new sources of supply—but in all areas we must protect the supplies we have."

In his resources message, the President proposed a more effective program of pollution control by: (1) increased federal financial assistance to state and interstate control agencies, (2) increased federal assistance to municipalities for construction of waste treatment facilities, (3) legislation to strengthen federal enforcement, and (4) an intensified federal research effort.

More than 30 bills have been introduced in Congress at the time of writing dealing with some aspects of water supply and pollution control. All this attention at the national level clearly indicates that water supply and pollution control are rising to their proper stature in government and in the public eye. It is none too soon.

By and large, the recommendations of the National Conference on Water Pollution, the Senate select committee, much of the proposed legislation, and the President are in agreement. Essentially, those recommendations would step up and extend the several authorities already written into the Federal Water Pollution Control Act.

Aim of Federal Law

Although the act delineates a supporting role in water pollution control with strong federal leadership, it makes clear the intent of Congress "to recognize, preserve, and protect the primary responsibilities and rights of the states in preventing and controlling water pollution."

The author wishes each of the other 49 states would recognize this responsibility as well as does Illinois. Testifying from this state before the Senate Select Committee on National Water Resources not long ago, the governor of Illinois said: "The prevention, abatement, and control of pollution . . . occupies a most important place in Illinois government. It is recognized that in this field of activity lies the greatest potential for making water available through its reuse."

The Federal Water Pollution Control Act goes beyond the usual public health legislation. It recognizes pollution control as a benefit for all water uses. It defines these uses as "public water supplies, propagation of fish and aquatic life and wildlife, recreational purposes, agricultural, industrial, and other legitimate uses."

The federal role in water pollution control is to support and aid technical research and to provide federal technical services and financial aid to states, interstate agencies, and municipalities. To implement this policy, the Water Pollution Control Act authorizes nine major activities: (1) development of comprehensive programs, (2) technical assistance, (3) research, (4) basic data, (5) enforcement, (6) construction grants, (7) program grants, (8) cooperation to control pollution from federal installations, and (9) interstate cooperation and uniform state laws.

Comprehensive Programs

In his recent natural resources message, President Kennedy referred to "the indispensable element of national leadership to develop comprehensive conservation plans for all of our great interstate river basins." In his address, he gave emphasis to the authority regarded as the most important function delegated to USPHS in the Federal Water Pollution Control Act. Comprehensive programing recognizes

the river basin as the logical unit for water resources development. It is an endeavor on the part of all communities and industries in the basin, and municipal, state, and federal governments, to cooperate in developing and carrying out a plan so that water resources can be used continuously without being degraded for the purposes they must serve.

A good illustration of this function can be found in Illinois. USPHS is just getting under way with a comprehensive study in the Great Lakes–Illinois River basins. Last year Congress appropriated $500,000 to begin this study. Congressional interest stemmed from litigation pending in the US Supreme Court. The situation arises from Chicago's diversion of Lake Michigan water to flush its wastes through the Illinois Waterway. This is opposed by other Great Lakes states which maintain that the diversion of water from Lake Michigan adversely affects shipping, hydroelectric power, and property values throughout the entire Great Lakes region. Other pollution problems—particularly since the opening of the St. Lawrence Seaway—added impetus to the need for the comprehensive basins study.

The broad goals on the Great Lakes–Illinois Waterway Basin Water Quality Project will be: (1) to determine the beneficial water uses that must be served now and in the predictable future, (2) to determine the pollution control and prevention measures that must be obtained to accommodate these beneficial uses, and (3) to establish a timetable for the achievement of the necessary remedial measures. These goals will require a full consideration of all the socioeconomic, legal, and technical factors bearing on the water resources of the basins. The plan will need to be flexible so that as these factors change, the plan can be adapted accordingly.

Surveys, investigations, and preparation of final reports and plans will require an estimated 6 years. This is the type of long-range planning that is needed in all major waterways of the United States, looking toward meeting accelerating water needs and apportioning them fairly. This is comprehensive basin development as Congress envisioned it in the 1956 Water Pollution Control Act.

Technical Assistance

A major element of the federal program is the provision of technical services on request by federal, state, interstate, municipal, and other agencies. These professional services are given by the staff at the Robert A. Taft Sanitary Engineering Center, Cincinnati, and by staffs in USPHS regional offices.

Requests usually come from a state, city, or industry with waste disposal problems of an unusual nature, problems for which they do not have adequate resources to solve by themselves. Requests may take the form of a full-scale river study or an evaluation of an agency's laboratory operations or of an industry's new waste treatment process. Agencies have requested investigations of such specialized problems as oil seepage on the Pacific Coast or brine pollution in the Arkansas–Red River Basin. The demands are many, and USPHS needs more skilled manpower and facilities to meet them.

The training courses at the Taft Center are familiar to many people. Usually lasting 1–2 weeks, they are advanced training or short refresher courses for engineers, chemists, plant operators, and others in some phase of the water supply or pollution control

business. Such training keeps the professional workers and technicians up to date on problems, needs, new devices, and techniques.

Research

There is a growing gap between what is known about water pollution and what is necessary to know. This has been especially true since World War II. In these years, countless new wastes from the chemical industry, of which little is known, have been introduced into the waterways. Radioactive materials also have entered the picture. In addition, the older problems have changed; for some of them there never were satisfactory solutions. By and large, the answers to these problems, old and new, must come from research.

The major part of USPHS research in water supply and pollution control is carried on at the Taft Center. An important new project is seeking advanced waste treatment techniques that will remove nearly all impurities from liquid wastes. Admittedly, this may be expensive, but it would help solve the growing and complex waste disposal problems of metropolitan areas like Chicago. There, as in a growing number of cities across the United States, today's best treatment processes fail to remove enough pollutants to avoid problems in the receiving stream. As water reuse increases, the residual buildup of wastes in many of our streams will make the waters unsuitable for downstream reuse unless waste treatment becomes more refined.

Other studies at the Taft Center have been concerned with industrial wastes that cause significant national or regional problems. Some of these wastes come from the beet sugar, steel, and pulp and paper industries, and some from naval stores and petroleum refining. Conservation and supplementation of water resources, improvements in existing waste treatment processes, microbiology, aquatic biology, land drainage, and methodology are among other subjects under investigation.

Although most of the research is carried out by USPHS staff members, some of it is done on contract with outside organizations such as universities. In addition, USPHS makes research grants for projects proposed by qualified individuals, organizations, colleges, and universities.

Basic Data

In recent years there has been growing concern over the lack of information on United States water resources. Collecting data is like keeping books on a business firm's assets and liabilities. In the water supply and pollution control business, records must be kept on the sources, kinds, and amounts of pollution reaching streams, and on the effect on water quality. These data are invaluable in planning pollution prevention and control.

Congress had this type of bookkeeping in mind when it provided in the Water Pollution Control Act that "the surgeon general shall collect and disseminate basic data on chemical, physical, and biological water quality and other information relating to water pollution, in cooperation with other federal, state, and local agencies having related responsibilities." Actually the whole field of activity is based on this type of information.

USPHS has established a National Water Quality Network of sampling stations on major interstate waterways to collect data and establish trends of improvement or deterioration of water quality. Seventy-five stations have been placed in operation cooperatively with state and local agencies. Even-

tually their number will be increased to 300. These are supplemented by several hundred intrastate stream stations operated by the state and local agencies themselves. The author understands that the Illinois Sanitary Water Board is sampling 175 stream locations and the effluents from more than 400 waste treatment plants. USPHS is working towards correlation of national, state, and local data from all over the country.

Last year USPHS, in cooperation with state conservation agencies, inaugurated a reporting system to determine the extent of pollution-caused fish kills. In the first 6 months, eight such fish kills were reported from Illinois. Estimated total kill was 103,000 fish. Affected was 51 mi of stream waters. Mining and industrial wastes were pinpointed when the cause could be determined. The Kankakee, Sangamon, and Des Plaines rivers, and several smaller streams, were scenes of the fish kills.

Inventories are also kept by USPHS on water supply and sewerage system facilities. This information is obtained through state water pollution control agencies. Other pertinent data, including contract awards and municipal bond sales, are compiled monthly and issued in annual reports.

Enforcement

Under the Federal Water Pollution Control Act, pollution of interstate waters is subject to abatement if it endangers the health or welfare of persons in a state other than that in which the discharge originates. The procedure calls for: (1) a conference called by the surgeon general with the state and interstate agencies involved, (2) a public hearing before a board appointed by the secretary of health, education, and walfare, and (3) federal court action. The second and third steps are taken only if the first one has not been effective. Enforcement actions under the act of 1956 have been taken in thirteen interstate stream pollution situations.

One such situation has involved Illinois and Missouri in the St. Louis metropolitan area. Municipal and industrial wastes discharged to the Mississippi River at that point interfered with use of the river water as a source of public water supply for recreation, scenic values, pleasure boating, sport fishing, navigation, and commercial fishing in both Missouri and Illinois.

USPHS held a conference on Mar. 4, 1958, at St. Louis. The conferees agreed on a time schedule with a final date of Jan. 1, 1967, for the construction of waste treatment facilities by the offending sources of pollution on both sides of the Mississippi River. While the time schedule has not in all cases been maintained, action to date has been reasonable. Missouri and Illinois communities and industries are in the process of providing facilities to control pollution.

Getting the state water pollution control agencies around the conference table, together with those responsible for an interstate pollution situation, is most helpful. This is being demonstrated in the St. Louis metropolitan area situation.

Construction Grants

The Federal Water Pollution Control Act is best known to the general public through its construction grants authority. This feature provides federal aid to municipalities in building sewage treatment plants. The community may receive up to 30 per cent of the project cost, not to exceed $250,000. Grants are made to those projects which have been certified by

the state water pollution control agency as having priority over other eligible projects, on the basis of financial as well as water pollution control needs. Thus the authority works as a cooperative federal-state-local program.

It has been very effective in stimulating construction and improvement of sewage treatment facilities throughout the country. In the nearly 5 years the program has existed, 2,581 projects have been approved for grants. The grants totaled $213,000,000, and supported construction costing 1.2 billion dollars. Every federal dollar has been met by $4.80 in local funds. There has been a 62 per cent rise in sewage treatment plant construction over a comparable period of preconstruction grant years.

Illinois has participated fully in this program. As of Feb. 28, 1961, 106 grants have been made in Illinois totaling $8,700,000, in support of projects having eligible costs totaling $45,900,000. These projects will serve 700,000 people, and when they are in operation, will result in improvement of approximately 900 mi of streams plus appreciable lake shore areas. All these projects were justified on the basis of public health necessity, although fifteen were also justified on the basis of needed improvements of Great Lakes waters and financial need.

Despite the significant gains made under the construction grants authority, the building of sewage treatment facilities is still far below national needs, as President Kennedy pointed out. To wipe out the present backlog of needs within a 5-year period and to take care of new ones arising from population growth and plant obsolescence will require annual expenditures varying from $715,000,000 in 1961 to $800,000,000 in 1965. This is considerably above the present annual average of $360,000,000.

Program Grants

A feature of the Water Pollution Control Act which seems little known by the public is that of program grants. Up to $3,000,000 a year is authorized for such grants to states and interstate agencies for extension and improvement of their water pollution control programs. The receiving agency must provide 33–66 per cent of the costs of their programs. Legislation is pending that would increase and extend the program grants beyond its present expiration date of Jun. 30, 1961.

Again, Illinois has made full use of the program grants feature. This state's allocation of these funds ($112,000 this year) amounts to about 40 per cent of its state program expenditure. The State Sanitary Water Board has been able to expand its staff, to establish an important branch office to serve the Chicago metropolitan area, and to acquire legal counsel for enforcement as a result of federal aid. It has also increased its basic data on waste facilities, physical plant, and operating data; it maintains better control over sewage works design and construction; and it has established an extensive stream and waste effluent sampling program since the program grants became available 5 years ago.

Control of Pollution From Federal Establishments

The Water Pollution Control Act directs federal agencies to cooperate with the Department of Health, Education, and Welfare and with states, interstate agencies, and municipalities in controlling pollution from federal installations. USPHS is now in process of inventorying such pollution and

will be responsible for providing technical and consultative services to all jurisdictions involved.

Interstate Cooperation

USPHS encourages the formation of interstate compacts for water pollution control by participating in negotiations and giving technical advice and assistance.

The Ohio River Valley Water Sanitation Compact is a good example of how this type of project works. Illinois is one of the nine participating states. During its decade of operation, this compact has demonstrated that such interstate agencies can effectively solve interstate water pollution control problems.

Illinois is also represented on the Great Lakes Compact Commission and the Bi-State Agency which includes the St. Louis–East St. Louis area on the Mississippi.

State Laws

In order to carry out its statutory responsibility of encouraging improved state laws, USPHS has issued a "Suggested State Water Pollution Control Act." Its principles have been used by 40 states. Illinois has good pollution laws to cope with its problems. Administration is centered in the State Sanitary Water Board, whose membership represents all interests. It is composed of the directors of the state departments of conservation, agriculture, public works, and health, plus representatives of industry and municipalities.

This is the type of multipurpose planning and interrelated action needed to expedite water pollution abatement. It is the same round-table type of structure used in the interstate compact, in comprehensive river basin development, and in the federal program mentioned above.

Water Pollution Control Advisory Board

A nine-member Water Pollution Control Advisory Board, appointed by the President, is authorized by Public Law 660. The members are chosen from industry, conservation, civic affairs, and state and local government—men who have demonstrated an active interest in water pollution control. Last year, Illinois was honored by one of these presidential appointments. Clair S. Boruff, technical director of Hiram Walker and Sons, Peoria, is one of industry's current representatives on the board. The chairman of the board is the surgeon general. The board advises, consults with, and makes recommendations to him on policy relating to his responsibilities under the Federal Water Pollution Control Act.

State Activities—*Richard S. Nelle*

A paper presented by Richard S. Nelle, Chief, Bureau of Stream Pollution, State Dept. of Public Health, Springfield, Ill.

Developed in England and modified by experience in the eastern United States, the common-law water rights doctrine has been interpreted in Illinois by the theories of natural flow and reasonable use. Stream pollution control laws not only express the reasonable-use theory, but they also establish statutory authority for the implementation of the laws, overriding

in many respects the common law.[1] Because other state water pollution statutes derive from various legal concepts and traditions, this discussion applies primarily to activities in Illinois and in other states, which have similar laws. Many principles of pollution control have general application.

Basis in Common Law

Common law granted to the riparian owner all the water that he needed for drinking, for household purposes, and for livestock. These were considered "natural" needs—needs essential to his existence and livelihood. Certain other uses were regarded as "artificial."

Included in "artificial" uses were those for comfort or for increasing prosperity. Irrigation of crops and industrial needs are examples of "artificial" use. But these artificial uses must be on a reasonable basis, and the courts establish no priority for the two uses mentioned.

In other considerations of water rights, the natural theory has prevailed in diversions of water, whereas reasonable use is more frequently applied in cases of pollution and consumption. Although the aquatic life in streams is considered public property, water rights are vested property rights of which the owner cannot be deprived except by due process of law. This means that riparian lands may be bargained for or acquired by compensation, and, for the public good, may be obtained by eminent domain where statutory authority permits.

Furthermore, water falling on the land and percolating into the soil is part of the land. Such ground waters may be used freely, but not maliciously, by the property owner even if the use interferes with other users on adjoining properties. Some legal minds believe that in a proper case the reasonable-use theory may prevail.

Pollution Control Laws

Stream pollution control laws developed from a need. It was all too clear that water pollution was no respecter of political boundaries, and that local government alone was ineffective in serving the interests of the general public. Consequently, even in those states with strong home rule, it followed that direction of water pollution control must come from the state government.

Statutes on water pollution control recognize that pollution is a menace to public health and welfare, that all legitimate interests must be protected, and that water may be used but not misused.[2,3] With an expanding industrial economy and a greater competition for water use, it is apparent that control of pollution * cannot be attained without control of use. Any use of water involves a change in water quality, and this quality must continue to be managed with increased precision and judgment as the relative quantity of water diminishes.

Quality requirements of water depend on the use. The quality of some waters required by certain industrial processes exceeds the most stringent demands for drinking water, yet in other processes even a polluted water

* As defined in the Illinois Sanitary Water Board Act, "pollution" means such alteration of the physical, chemical, or biological properties of any waters of the state, or such discharge of any liquid, gaseous, or solid substance into any waters of the state as will or is likely to create a nuisance or render such waters harmful or detrimental or injurious to public health, safety, or welfare, or to domestic, commercial, industrial, agricultural, recreational, or other legitimate uses, or to livestock, wild animals, birds, fish, or other aquatic life.

is acceptable. Recreational waters must not contain substances harmful or toxic to aquatic life. Agricultural waters must be low in certain elements and compounds that adversely affect soil structure. Domestic waters should be clear, of low mineral content, free from pathogenic organisms and harmful chemicals, and free from materials causing tastes and odors.

As in the common-law tradition, a water supply for mere existence is a top-priority use. Few public water impoundments are devoted exclusively to drinking and household needs, but if quantity is wanting, the powers that control water distribution may limit use to that purpose only. Water for daily needs is a precious commodity, and protection of the source of supply cannot be a careless duty if the public good is to be properly served.

Local Powers

Previously it was pointed out that control of pollution is administered at the state level of government. This observation does not relieve local government from exercising authority delegated to it. Statutes give power to municipalities and special-purpose districts to plan, to construct, and to police water sources within certain limitations.[4-7] In many instances these powers are not used, but where health and safety are concerned, the permissive language of the statutes should not be construed as being other than mandatory.

Ideally, a watershed or an aquifer should be free from all sources of actual or potential pollution. Except in uninhabited regions, or for small isolated areas, this ideal cannot be achieved. Ordinarily, there are other legitimate users of water in the drainage basin. Hence it follows that water quality must be managed so that the uses will not be impaired, with special consideration given to use for domestic purposes.

Even though a water treatment plant can adequately treat highly contaminated waters, it is unwise to place undue reliance on equipment or personal factors. When the source is good, the finished water is more likely to be potable. Yet in used waters there are substances that defy removal or require special methods to obtain substantial removal. Among these materials are surface-active agents originating in detergents, chlorides from various sources, and literally hundreds of undetectable substances originating from chemical industries, from weed, insect, and rodent control, and from other activities. Radioactive substances should not be overlooked.

Planning at State Level

Control of watershed pollution is a cooperative venture. Local government is charged with this responsibility, and is aided by state assistance or state control for areas beyond the reach of local authority. The first responsibility is planning.

Planning involves the obvious consideration of quantity, but more importantly, it includes determinations of watershed use, industrial locations, recreational demands, sewage works, agricultural pursuits, and many other activities that may affect water quality. At the state level, planning is receiving increasing attention, and several Illinois agencies cooperate to assist local government. Planning for land use is essential, and the enactment of ordinances for building and zoning, waste collection and disposal, and use of waters is fundamental to good planning. In this planning, the state water

pollution control authority prescribes a degree of waste treatment consistent with the stream use. Certain pollutants are restricted in amounts, or, when possible, are eliminated from waste discharges. Disinfection of treated sewage wastes is a usual requirement, in addition to tertiary treatment where indicated.

State Authority

At the state level, waste treatment works and waste producers are required to report periodically the quality of effluents, especially where a particular quality of water is required downstream. Unusual discharges, sewage bypassing, industrial spills, or escaping wastes are reported by the conscientious waste producer, and, as a further measure, an extensive water quality program provides for surveillance of feeder streams.

Proposed sewage works or industrial-waste works must receive a state permit for construction and operation, such a permit being granted only when the design provides for an adequate degree of treatment for discharge to the receiving stream. Furthermore, such works must be operated by properly trained and qualified personnel. Training is provided by special courses, general technical conferences, dissemination of information, and personal visits of water pollution field staff members and of state laboratory personnel. Knowledge is also acquired by voluntary operator groups in periodic technical meetings. In this respect, it is most heartening to see local groups springing up naturally by area and by drainage basin. The state encourages these groups but prefers that they operate by their own rules and be given assistance only when requests are initiated locally.

Cooperation Between State Agencies

To name the specific interests and contributions by state agencies would require a lengthy list, but it is worth mentioning that present progress in pollution control is significantly enhanced by the all-time high level of cooperation between state agencies. Without scientific data and agency records, it would be difficult to provide a comprehensive and meaningful pollution control program.

Investigations are mandatory upon complaints to the state, and desirable for surveillance. Frequently state agencies other than the stream pollution control board are called upon for assistance, and conversely, the help of the board is often requested to resolve problems of other departments. An investigation reported to the pollution control board may result in informal hearings and voluntary correction of pollution. When voluntary action is not forthcoming, the board proceeds with hearings and eventually may issue an order that is enforced through the courts by the state attorney general.

Board action or court orders are important in financing corrective sewage or waste works. In a proper instance a court may order a community to build abatement facilities without the approval of the people for issuance of general-obligation or revenue bonds. This type of decision is a relatively new application of the legal concept that the necessities of public health, welfare, and safety are more important than the preference of a community.

Conclusion

The functions of state government are manifold in their services to lower governmental agencies, particular and special attention being given to public

water supplies. The duties, responsibilities, and actions of the state stream pollution control board require and receive the cooperation of other agencies of state government. Local governments should use the pollution control powers granted them by statute in the enactment and enforcement of suitable ordinances, using state level assistance for guidance and for control beyond the limitations of their powers.

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2. Illinois Revised Statutes. Sanitary Water Board Act, Chap. 19, Para. 145.1–145.18.
3. Sanitary Water Board Act. Circ. 826. Illinois Dept. of Public Health, Springfield, Ill. (1960).
4. Illinois Revised Statutes. River Conservancy Districts, Chap. 42, Para. 403, Sec. 20.
5. Illinois Revised Statutes. Municipalities, Chap. 24, Para. 74-2.
6. Illinois Revised Statutes. Cities and Villages, Chap. 24, Para. 75-3.
7. Illinois Revised Statutes. Water Authorities, Chap. 111 2/3, Para. 249, Sec. 26.

Correction

The article by A. P. Black and Donald G. Willems, "Electrophoretic Studies of Coagulation for Removal of Organic Color" (May 1961 Journal, Vol. 53, pp. 589–604), contained an error. On p. 600, right-hand column, line 22 from the bottom, "orthokinetic" should read "electrokinetic."

Behavior of Radionuclides on Ion-Exchange Resins

Dade W. Moeller, George W. Leddicotte, and Sam A. Reynolds

A contribution to the Journal by Dade W. Moeller, Chief, Radiological Health Training Activities, Div. of Radiological Health, Robert A. Taft San. Eng. Center, Cincinnati, Ohio; George W. Leddicotte, Leader, Nuclear Analyses Group, Analytical Chemistry Div., Oak Ridge National Lab., Oak Ridge, Tenn.; and Sam A. Reynolds, Leader, Radiochemical Research & Development Group, Analytical Chemistry Div., Oak Ridge National Lab., Oak Ridge, Tenn.

A STUDY was made of the behavior of radionuclides on ion-exchange resins used for the decontamination of cooling water in a nuclear reactor. The principal objectives of the investigation were identification of the nuclides, measurement of their relative concentration as a function of bed depth, and interpretation of these data in the light of the effective performance of the system.

Equipment

Because it was available and suitable for the purposes stated, the low-intensity test reactor (LITR) at the Oak Ridge National Laboratory, Oak Ridge, Tenn., was used in the study. This heterogeneous, enriched-uranium reactor is water moderated and cooled. Fuel elements consist of aluminum-uranium alloy with aluminum cladding.

The reactor is normally operated at a power level of 3,000 kw, has an average flux of 2.2×10^{13} neutrons/sq cm /sec, and is cooled by water recirculated through the reactor at 1,200 gpm. About 3 per cent of the coolant flow (approximately 40 gpm) is bypassed through a series of ion-exchange columns for removal of radionuclide impurities arising from fission product contamination and neutron bombardment of stable elements in the water during its passage through the reactor core. The system is shown in Fig. 1.

The ion-exchange decontamination system consists of three resin columns in series—a cation, an anion, and a mixed-bed unit. Actually, there are two cation and two anion columns,* one of each type in use at all times. The system has only one mixed-bed unit. The units may be described as:

1. *Cation units,* two columns, 24 in. in diameter and 46 in. high, each containing 8 cu ft of resin
2. *Anion units,* one column, 24 in. in diameter and 37 in. high, containing 6 cu ft of resin; and one column, 18 in. in diameter and 39 in. high, containing 3.5 cu ft of resin
3. *Mixed-bed unit,* one column, 36 in. in diameter and 96 in. high, containing 20 cu ft of anion resin and 14 cu ft of cation resin.

* The cation columns contained IR-120 resin; anion columns contained IRA-410 resin. The resins are manufactured by Rohm & Haas Co., Philadelphia, Pa.

The buildup of radionuclides on the beds results in exposure doses, on the order of roentgens per hour, outside the columns. As the anion unit is apparently more susceptible to radiation damage, the cation bed is put before it to avoid as much exposure as possible to the anion bed. To protect personnel nearby, the cation units are shielded by a rectangular wall of 12-in. barytes block. The anion units are shielded by a 6-in. concrete block wall on three sides and share one wall of 12-in. barytes block with the cation units on the fourth side. The shielding serves also for weather protection. The units are covered by a conventional metal roof. Figure 2 shows the system during construction.

At the time of sample collection, the cation and mixed-bed units had been in use for 7 weeks; the anion unit, 2 weeks. All three beds were new, and the cation and anion columns had never been regenerated. The mixed-bed unit had been regenerated once, its average life cycle being about 4 weeks, during which time about 1.5 mil gal of water had passed through it. Regeneration of the unit was based on measurements of the specific resistance of its effluent—that is, when the specific resistance decreased to or near the resistance of the cooling water in the main system, the unit was considered depleted. Regeneration with nitric acid and sodium hydroxide had been performed about 2 weeks prior to sample collection. Average specific resistance of the cooling water in the reactor was about 810,000 ohm-cm.

TABLE 1

Radionuclide Composition of Cooling Water

Radionuclide	Half-Life	Estimated Concentration* $\mu c/ml$
Na^{24}	15.0 hr	3×10^{-3}
I^{131} +daughter products	8.05 days	3×10^{-3}
I^{132}	2.3 hr	
I^{132} +daughter products	21 hr	
I^{135} +daughter products	6.7 hr	
Cu^{64}	12.9 hr	1×10^{-3}
Tc^{99m}†	6.0 hr	7×10^{-4}
Mn^{56}	2.58 hr	7×10^{-4}
Np^{239}	2.36 days	6×10^{-4}
$Sr^{91}+Y^{91m}$†	9.7 hr +50 min	6×10^{-4}
$Ba^{140}+La^{140}$	12.8 days +40.2 hr	1×10^{-5}
Pa^{233}	27.0 days	1×10^{-5}
Co^{60}	5.27 yr	1×10^{-5}

* At time of sample collection.
† The letter *m* following the mass number of a radionuclide indicates an isomeric state.

TABLE 2

Radionuclides Identified on Ion-Exchange Resins

Radionuclide	Half-Life*	Principal Gamma Emissions* *Mev*	Resin Column Containing Nuclide
Na^{24}	15.0 hr	1.37, 2.75	cation
Np^{239}	2.36 day	0.10, 0.22, 0.28	cation
Zn^{65}	245 day	1.11	cation
Co^{60}	5.27 yr	1.17, 1.33	cation & mixed bed
Ba^{140}	12.8 day	0.03, 0.54	cation
$+La^{140}$	40.2 hr	0.49, 1.60	cation
I^{131}	8.05 day	0.364	anion & mixed bed
I^{132}	21 hr	0.53	anion & mixed bed
Mo^{99}	67 hr	0.14†	anion & mixed bed§
$+Tc^{99m}$‡	6.0 hr	0.14	anion & mixed bed§
Te^{132}	78 hr	0.23	anion§
$+I^{132}$	2.3 hr	0.67, 0.78	anion§
Cr^{51}	27.8 day	0.32	anion
Ce^{141}	32.5 day	0.146	mixed bed
Sb^{124}	60 day	0.60, 1.69	mixed bed§

* From Reference 6.
† Low intensity.
‡ The letter *m* following the mass number of a radionuclide indicates an isomeric state.
§ Presence not confirmed.

The range of concentrations of radioactive materials in the coolant and the typical removals effected by each of the resin columns are shown in Fig. 3. The count-per-minute activity in the raw coolant entering the cation bed corresponds to about 0.01 $\mu c/ml$. The principal radionuclide composition of the coolant is shown in Table 1.

Past Studies

As a corollary to the rapid detection of fuel-cladding failures, Heath [1] de-

termined the radionuclides in the recirculating cooling water of the materials-testing reactor at the National Reactor Testing Station, Idaho Falls, Idaho. Lyon and Reynolds [2, 3] made studies in 1954 of the radionuclides in LITR cooling water. In each of these studies, use was made of gamma spectrometry, decay studies, and radiochemical methods. None of these solved elements in water by neutron bombardment, providing additional information on radioactive materials to be expected in cooling water systems.

Present Study

Resin samples, collected at 6-in. depth intervals from each of the three columns, were dried and their gross gamma radioactivity determined with

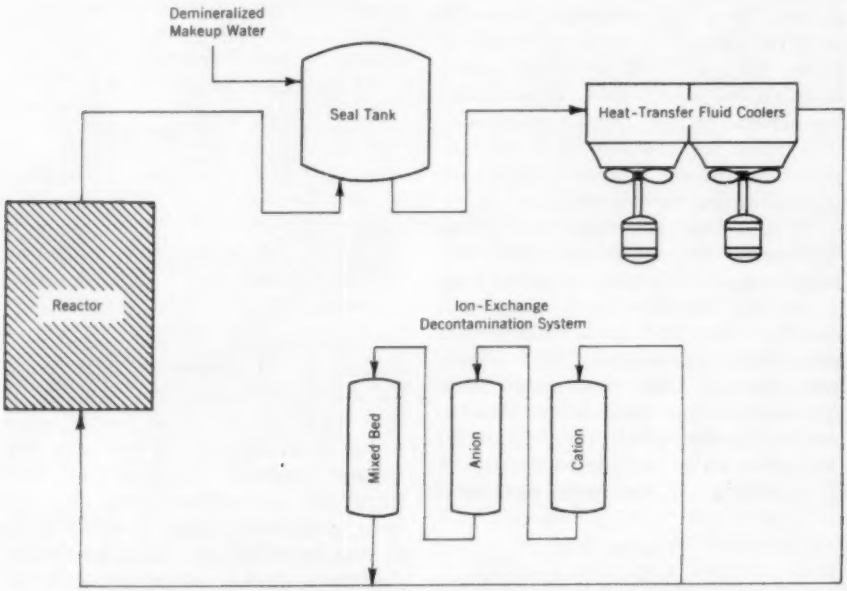

Fig. 1. Cooling System of Low-Intensity Test Reactor

The ion-exchange decontamination system consists of three resin columns in series: a cation, an anion, and a mixed-bed unit.

workers attempted a detailed study of the behavior of nuclides on the resin beds.

Moeller, Leddicotte, and Reynolds [4] described the radionuclides in the reactor cooling water of the LITR and at the effluent sides of the cation, anion, and mixed-resin beds. Blanchard, Leddicotte, and Moeller [5] made detailed studies of the activation of dis-

the use of a NaI(Tl) well-type crystal detector. The activity of each sample, 1 day after sample collection, is shown in Fig. 4. It will be observed that all three beds exhibited a similar relative distribution of activity with bed depth, ranging from the highest concentrations at the surface to the lowest at the bottom. Total concentrations on the cation and anion resins were com-

parable, with the mixed bed having, as expected, much lower overall levels. With an assumed counting efficiency of 33 per cent and an emission by each radionuclide contaminant of one gamma photon per disintegration, gross activity levels at the surface of the cation column were about 100 μc/g (dry weight) of resin.

vealed that the highest concentration of short-lived materials was near the surface of the columns and that the migration time of the nuclides down the beds was long in comparison to the half-lives of the short-lived components.

Concurrent gamma spectrometric determinations were made on resin samples from the surface and bottom

Fig. 2. Ion-Exchange Units of Low-Intensity Test Reactor

Resin samples are obtained from sampling ports, one of which is indicated in the photograph.

Data on the gross gamma decay of selected samples for 1 month after collection are shown in Fig. 5. For all three resins, samples from the surface of the beds showed a more rapid decay than samples collected farther down in the columns. These differences, more marked for the cation resin than for the anion or mixed-bed resin, re-

of each column. Data on the composition of the radioactive materials at these depths were deemed important because: (1) radionuclides in the upper levels of the bed should be most effectively removed from the water in its passage through a particular column; (2) the presence of radionuclides at the bottom of the bed indicates that

the column is near saturation for these particular materials and that they are probably not being effectively removed from the water.

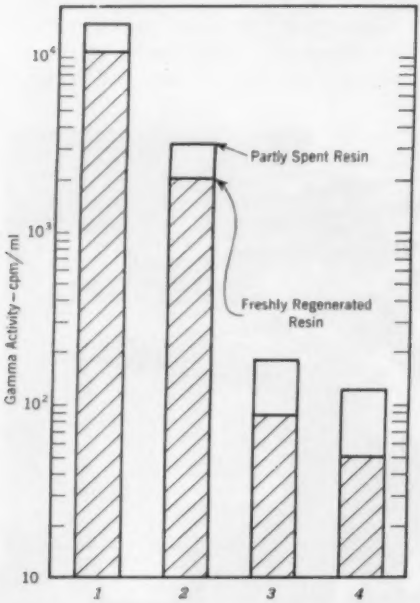

Fig. 3. Gross Gamma Activity in Cooling Water

Shown is the range of gross gamma activity of LITR cooling water at various stages in the ion exchanger decontamination system. A gamma scintillation counter was used to measure the activity of 1-ml aerated samples. Activity determinations were made 20 min after sample collection. Numbers beneath bars represent: 1, cation exchanger influent; 2, cation exchanger effluent; 3, anion exchanger effluent; and 4, mixed-bed exchanger effluent.

Cation Resin

Gamma spectral data for a sample of surface level cation resin are shown in Fig. 6 and 7. Shown on these curves, as well as on the curves in Fig. 8–11 pertaining to other resin samples, is the approximate energy of each photopeak, measured in millions of electron volts (Mev). Identification of the radionuclides corresponding to each photopeak will be discussed in reference to the energy values shown on the curves, rather than in reference to the latest published values given in a tabulation of results [6] published after this study.

For the surface sample, the predominant radionuclide the first few days after sampling was 15.0-hr Na^{24}, as characterized by the 1.34-Mev and 2.75-Mev gamma peaks in Fig. 6. Undoubtedly other short-lived nuclides were also present, but the excess activity of Na^{24} completely overshadowed their contribution to the total spectra. After decay of Na^{24}, the predominant activity was due to 2.36-day Np^{239}, shown by the 0.10-Mev and 0.21-Mev gamma peaks in Fig. 7. With further decay, 245-day Zn^{65} appeared. This nuclide is characterized by the gamma peak at 1.10 Mev. The long-lived 1.34-Mev peak represents 5.27-year Co^{60}, its 1.17-Mev gamma peak being overshadowed by the 1.10-Mev peak of Zn^{65}. The 0.47-, 0.80-, and 1.59-Mev peaks probably represent 40.2-hr La^{140}, the daughter product of 12.8-day Ba^{140}.

Gamma spectral data for a resin sample from the bottom of the cation exchanger are shown in Fig. 8 (left). In this sample, as in the surface level sample, the presence of Co^{60} and Zn^{65} is indicated by the characteristic long-lived 1.34-Mev and 1.11-Mev peaks, respectively. Again, the characteristic 0.50-, 0.83-, and 1.59-Mev peaks of La^{140} are present.

The sharp drop in activity with time, as shown in Fig. 5, is readily explainable in terms of the rapid decay of

Na^{24} with its 15-hr half-life, followed by Np^{239} with its 2.36-day half-life. Decay of 12.8-day Ba^{140} and its daughter product La^{140}, 245-day Zn^{65}, and, finally, Co^{60} would then follow much more slowly. As anticipated, older samples (Fig. 8, left) show increasingly larger amounts of Co^{60} and Zn^{65} relatively.

Anion Resin

Gamma spectral data for a surface level resin sample from the anion column are shown in Fig. 8 (right). The predominant radioactive nuclides initially present are 67-hr Mo^{99} and its daughter product 6.0-hr Tc^{99m}, as indicated by the 0.14-Mev gamma peak; 8.05-day I^{131}, as shown by the 0.37-Mev peak; and 21-hr I^{133}, as shown by the 0.54-Mev peak. Also probably present in lesser concentration is 78-hr Te^{132} and its daughter product 2.3-hr I^{132}, as shown by the small 0.24-Mev and 0.68-Mev gamma peaks. After several weeks of decay, I^{131} remains the principal source of activity.

Gamma spectral data for a bottom level resin sample from the anion column are shown in Fig. 9. The predominant radioactive nuclide initially present was 8.05-day I^{131}, as characterized by the 0.368-Mev gamma peak. The presence of 67-hr Mo^{99} and 6.0-hr Tc^{99m} is shown by the 0.143-Mev gamma peak. It is probable that 27.8-day Cr^{51} was also present, as it has a characteristic gamma peak at 0.32 Mev.

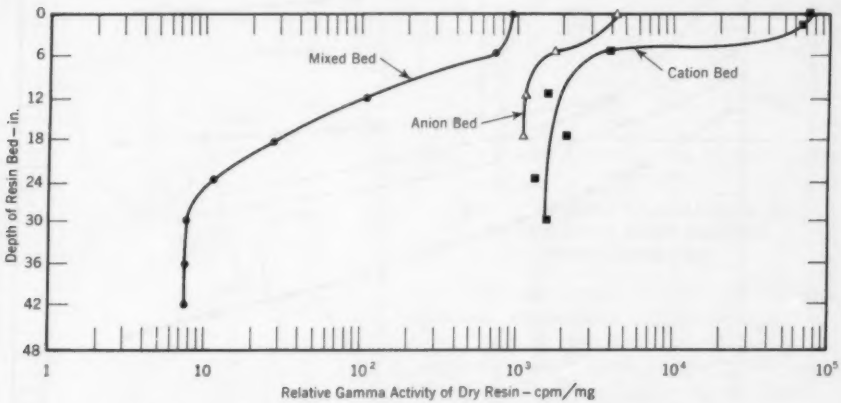

Fig. 4. Gamma Activity as Function of Resin Bed Depth

All three beds had a similar relative distribution of activity with bed depth. The highest activity concentrations were at the surface of the bed; the lowest concentrations, at the bottom of the bed.

Mixed-Bed Resin

Gamma spectral and decay data for a surface level sample from the mixed-bed column are shown in Fig. 10. Radioactive nuclides initially in predominance are 8.05-day I^{131} and 21-hr I^{133}, as characterized by the 0.37-Mev and 0.55-Mev gamma peaks. The presence of 67-hr Mo^{99} and 6.0-hr Tc^{99m} is shown by the 0.14-Mev peak.

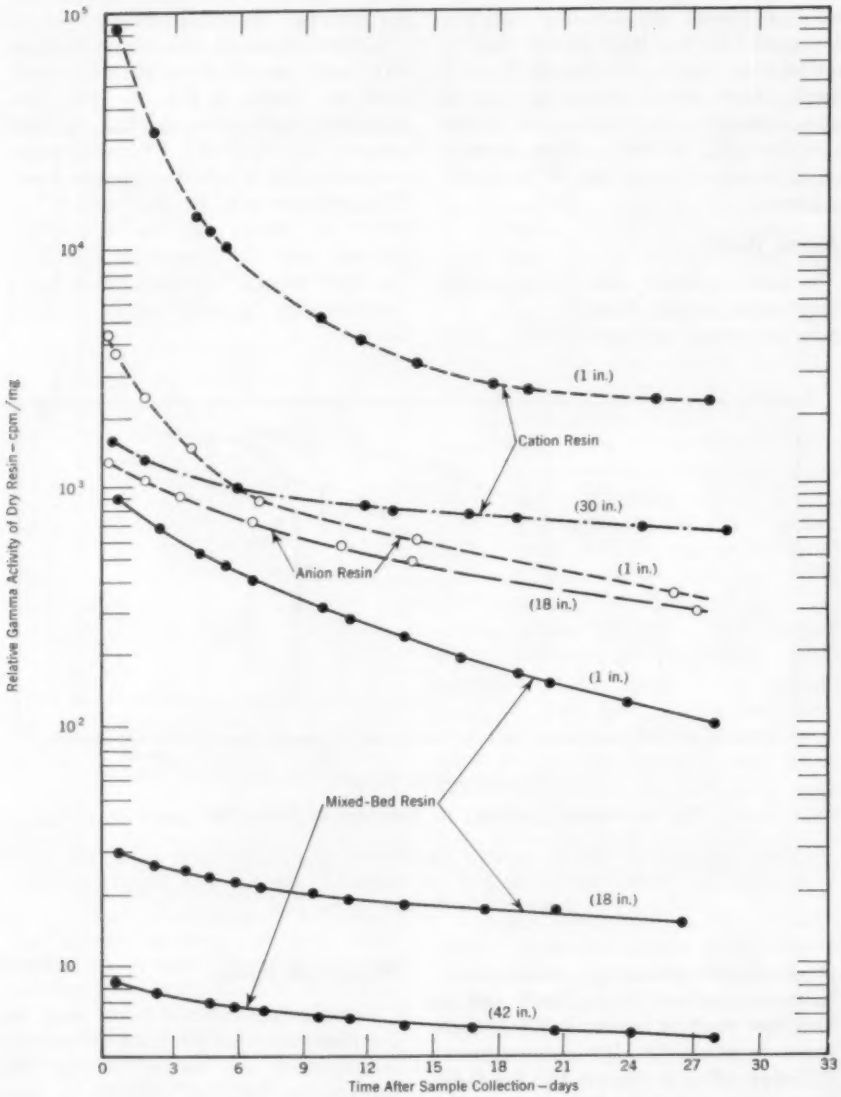

Fig. 5. Gross Gamma Decay as Function of Resin Bed Depth

For all three resins, samples from the surface of the beds showed a more rapid decay than samples collected farther down in the columns.

The radionuclide associated with the 0.58-Mev and 1.69-Mev peaks is probably Sb^{124}.

Gamma spectral data for the bottom level resin sample from the mixed-bed column are shown in Fig. 11. Radioactive nuclides in evidence are 32.5-day Ce^{141}, as indicated by a 0.14-Mev peak; and Co^{60}, as shown by the 1.15-Mev and 1.35-Mev peaks. The source of the 0.63-Mev peak was not identified, but it may be indicative of 30-year Cs^{137}. The source of the 1.55-Mev peak is also unknown.

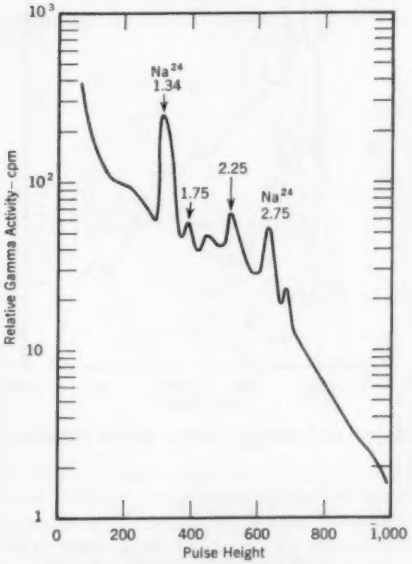

Fig. 6. Gamma Spectral Data for Surface Level Resin Sample: Cation Exchanger

Activity was measured with a single-channel gamma scintillation spectrometer. The spectrum was recorded 24 hr after sample collection. Values on the curves are the approximate energy of each photopeak measured in millions of electron volts.

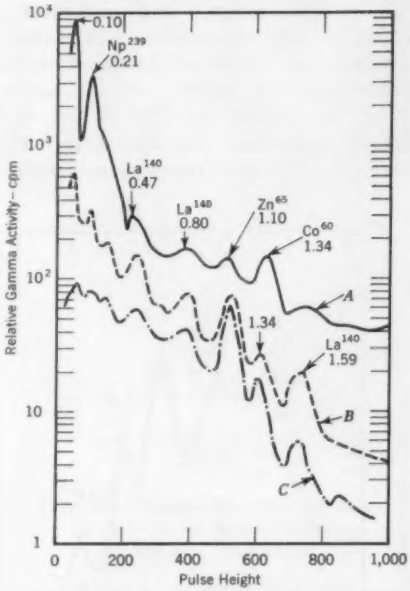

Fig. 7. Gamma Spectral Data for Surface Level Resin Samples: Cation Exchanger

Activity was measured with a 20-channel gamma scintillation spectrometer. The recording of the spectrum was made at different times after sample collection: for Curve A, 3 days after sample collection; B, 12 days after collection; and C, 43 days after collection. Values on the curves are the approximate energy, in millions of electron volts, of each photopeak for specific radionuclides.

The predominant radionuclides identified on each of the three resin columns, their half-lives, and principal gamma emissions are listed in Table 2.

Summary and Comment

A study of the ion-exchange decontamination system for the recirculating cooling water of the low-intensity test reactor revealed that, in

the cation, anion, and mixed-bed columns, the concentration of radionuclides on the resin decreased with increasing bed depth. At the same time, the overall half-life of the retained materials simultaneously increased. As anticipated, considerable variation with depth was observed in relative radionuclide composition—the shorter lived materials predominating near the surface, the longer lived near the bottom of each column. These facts support theoretical predictions and, when considered in detail, lead to important implications.

The data emphasize the care required in using data on gross radioactivity removals for the evaluation of the efficiency of an ion-exchange system. This is true because the effluent, although exhibiting a "satisfactory" reduction in gross activity, may actually contain a significantly greater proportion, as well as actual concentration, of longer lived radionuclides. Later studies of the anion column corroborated this observation. They showed that iodine, which is apparently loosely retained by the resin, migrates rather rapidly through the bed.

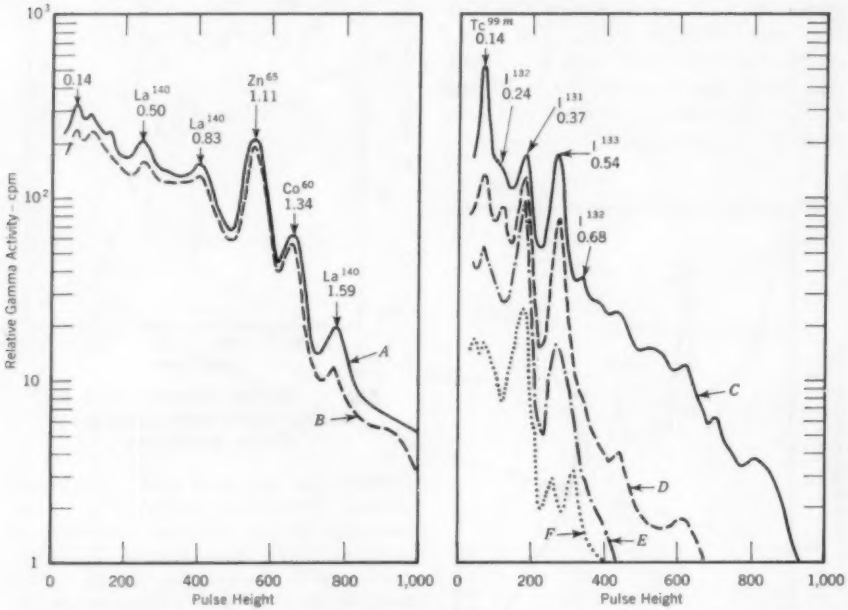

Fig. 8. Gamma Spectral Data for Bottom Level and Surface Level Resin Samples

The samples for the curves at the left were from the LITR cation exchanger (bottom of resin bed); for the curves at the right, from the anion exchanger (surface level of resin bed). Activity of all samples was measured with a 20-channel gamma scintillation spectrometer. The recording of the spectrum was made at these times after sample collection: for Curve A, *21 days;* B, *43 days;* C, *1 hr;* D, *22 hr;* E, *3 days; and* F, *19 days. Values on the curves are the approximate energy, in millions of electron volts, of each photopeak for specific radionuclides.*

As the bed approaches saturation, the predominant material reentering the emerging liquid at the bottom of the bed is I^{131}, with the time of retention on the bed short in comparison to the half-life of this isotope, but long in comparison to its shorter lived isotopes (such as I^{133}).

Thus, as a general rule, it can be anticipated that the removal efficiency of an ion-exchange column will be least for those radionuclides whose half-lives are long in comparison to their retention time. And the breakthrough of these radionuclides may be significant some time before column saturation, as indicated by the removal of accompanying shorter-lived materials.

It must be emphasized, however, that this variation in removal efficiency with half-life is a physical phenomenon and is not inherently related to the chemistry of the radionuclides. Only if the half-lives of all radionuclides in the sample were extremely long in comparison to their retention time would the activity actually reflect the true distribution of ions on the columns and the chemical affinity of the resin for each radionuclide. If the affinity is not equal, those radionuclides most tightly bound will be found in greatest concentration near-

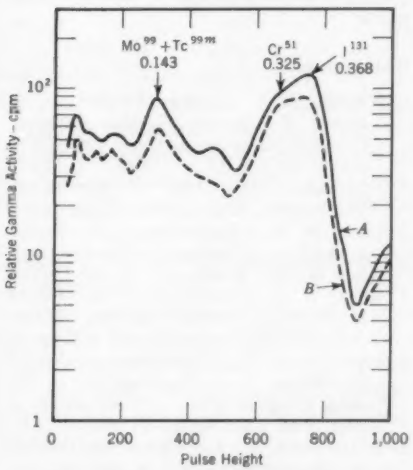

Fig. 9. Gamma Spectral Data for Bottom Level Resin Sample: Anion Exchanger

Activity was measured with a 20-channel gamma scintillation spectrometer. The recording of the spectrum was made at different times after sample collection: for Curve A, *4 days after collection; and for Curve* B, *8 days after collection. Values on the curves are the approximate energy, in millions of electron volts, of each photopeak for specific radionuclides.*

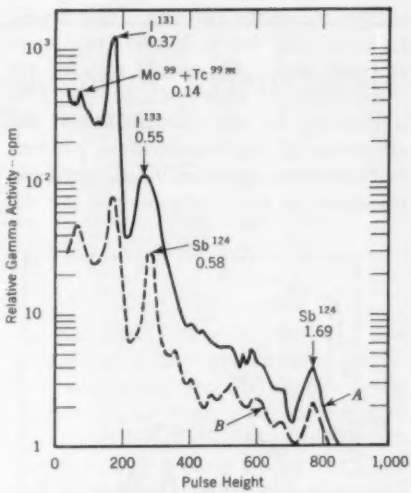

Fig. 10. Gamma Spectral Data for Surface Level Resin Sample: Mixed-Bed Exchanger

Activity was measured with a 20-channel gamma scintillation spectrometer. The recording of the spectrum was made at different times after sample collection: for Curve A, *3 days after collection; and for Curve* B, *34 days after collection. Values on the curves are the approximate energy, in millions of electron volts, of each photopeak for specific radionuclides.*

est the top of the column. This would be true only for a column composed of fresh resin. On an old column, the distribution of radionuclides would be influenced by the thoroughness and efficiency of the regeneration process.

These concepts may have equal implications in the evaluation of the use of the cation-exchange capacity of the soil for the discharge of radioactive wastes—through seepage pits, for example. Although samples collected nearby may indicate satisfactory reductions in gross activity levels, the contribution of the long-lived radionuclides to the total activity may have increased significantly.

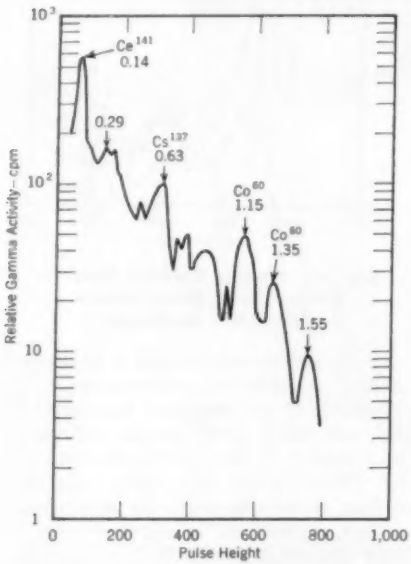

Fig. 11. Gamma Spectral Data for Bottom Level Resin Sample: Mixed-Bed Exchanger

Activity was measured with a 20-channel gamma scintillation spectrometer. The spectrum was recorded 26 days after sample collection. Values on the curves are the approximate energy, in millions of electron volts, of each photopeak for specific radionuclides.

The foregoing statement, however, may not apply in every instance. For example, at Oak Ridge, the reduction in activity in intermediate level fission product wastes discharged to seepage pits is primarily due to the retention on the soil of the longer lived Cs^{137} and Sr^{90}. The bulk of the activity remaining in the waste as it seeps through the soil is due to shorter lived Ru^{106}.

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Suggested Method for Turbidimetric Determination of Sulfate in Water

John R. Rossum and Primo A. Villarruz

A contribution to the Journal by John R. Rossum, San. Engr.; and Primo A. Villarruz, Asst. San. Engr.; both of California Water Service Co., San Jose, Calif.

TURBIDIMETRIC determination of sulfate offers substantial savings in time over the classical gravimetric method, and is considered by some analysts to be equally accurate, particularly in the lower ranges of sulfate concentration encountered in fresh water.

In 1946, the authors mechanized the method of Sheen and Kahler [1] by employing a photometer to replace the visual turbidimeter and a magnetic mixer controlled with an electric timer to replace manual stirring. At that time, similar equipment was available in many water laboratories and others probably adopted essentially these same modifications. A cursory investigation indicated that the method was generally suitable for low sulfate concentrations, and it has been used for routine work in the authors' laboratory for many years. In 1951, the convenience of this procedure was called to the attention of the Standard Methods Committee and the method was published in the tenth edition [2] as tentative. With further modification, the procedure has been published as a standard method in the eleventh edition.[3]

Investigations of Method

No critical evaluation of the variables involved has been published. Thomas and Cotton [4] compared the method with the gravimetric procedure, concluding that the turbidimetric procedure was more accurate and precise. The USPHS Analytical Reference Service [5] reports 38 results from 31 laboratories showing the gravimetric procedure to have superior precision and accuracy. Two of the ten laboratories using the turbidimetric method report values that are so grossly different from the others as to justify discarding the results. If these are omitted, the standard deviations for the two methods are not significantly different, even though the high concentration of 288 mg/l sulfate should favor the gravimetric procedure.

In view of the status accorded to the turbidimetric procedure in *Standard Methods* and the apparent popularity of the method, an investigation of some of the variables involved was undertaken and a significantly improved procedure was developed. The results of this investigation cannot be easily summarized and are too lengthy to be suitable for publication. A limited number of copies of a report of this investigation are available from the authors.

The variables investigated are:

1. Technique of adding barium chloride
2. Quantity of barium chloride added

3. Size of barium chloride crystals
4. Addition of alcohol and glycerine to reagents
5. Effect of common cations and anions
6. Effect of color, turbidity, and surfactants
7. Acid concentration
8. Stirring speed
9. Time of stirring
10. Time of standing
11. Temperature
12. Volume of flask
13. Size of magnet
14. Optics of photometer
15. Use of nephelometer or turbidimeter.

TABLE 1

Maximum Permissible Concentrations of Inorganic Ions

Ion	Concentration *mg/l*
Calcium	1,000
Magnesium	1,000
Sodium	2,000
Potassium	100
Nitrate (as NO_3)	100
Alkalinity (as $CaCO_3$)	750
Silica (as SiO_2)	1,000
Phosphate (as PO_4)	10

1. General Discussion

1.1. *Principle.* Sulfate is precipitated from solution with barium in such a manner as to form a suspension having reproducible optical absorbance. The sulfate concentration is determined from the absorbance of the resulting suspension using a previously prepared calibration curve.

1.2. *Interference.* Color and turbidity interfere. If the sulfate concentration is less than 15 ppm, color and turbidity may be removed by flocculation with aluminum chloride or ferric chloride, but in samples with higher sulfate concentrations, the loss of sulfate in the floc becomes serious. The corrections for color and turbidity indicated in Sec. 4.1 are fairly satisfactory if the absorbance from the interference is not more than 10 per cent of the absorbance resulting from the barium sulfate precipitate.

Organic matter may interfere: (1) by forming insoluble compounds with barium—for example, higher fatty acids; (2) by complexing barium—for example, citrate ion; or (3) by inhibiting crystal formation—for example, surfactants. Alkyl benzene sulfonate does not interfere in concentrations up to 5 mg/l. Filtration of the sample through activated carbon satisfactorily removes most organic interference, but if the sulfate concentration in the sample exceeds 15 mg/l, there is appreciable loss of sulfate.

Inorganic constituents should not exceed the values shown in Table 1.

In most instances, dilution is the best method of eliminating the effect of interfering substances.

2. Apparatus

2.1. *Magnetic stirrer.* The magnetic stirrer should be capable of stirring a 60-ml volume in a 250-ml flask at a reasonably constant speed such that splashing does not occur and that 0.3 g 20–30-mesh barium chloride crystals completely dissolve in 10–30 sec. If several magnets are to be used, they should be of approximately the same size and shape.

2.2. *Photometer.* One of the following is required:

a. *Spectrophotometer,* for use at 420 mμ, providing a light path of at least 1 cm, and preferably 4 cm.

b. *Filter photometer,* equipped with a blue filter having a maximum transmittance at about 420 mμ, and providing a light path of at least 1 cm, and preferably 4 cm.

2.3. *Timing device.* A clock or stop watch that can be read to the nearest second. A laboratory electric stop clock with a straight reading dial that can be read to the nearest 0.01 min is recommended for convenience.

2.4. *Spoon.* A metal spoon calibrated to contain between 0.25 and 0.35 g 20–30-mesh barium chloride crystals, and capable of delivering its contents with a reproducibility of ±10 per cent.

3. Reagents

3.1. *Buffer solution (I).* Dissolve 30 g $MgCl_2 \cdot 6H_2O$, 5 g $CH_3COONa \cdot 3H_2O$, 1.0 g KNO_3, and 20 ml CH_3COOH (99 per cent or more) in about 500 ml, and make up to 1 liter.

3.2. *Buffer solution (II)* (required when the sulfate concentration in the sample is less than 10 mg/l). Dissolve 30 g $MgCl_2 \cdot 6H_2O$, 5 g $CH_3COONa \cdot 3H_2O$, 1.0 g KNO_3, 0.111 g Na_2SO_4, and 20 ml CH_3COOH (99 per cent or more) in about 500 ml and make up to 1 liter.

3.3. *Barium chloride crystals.* $BaCl_2 \cdot 2H_2O$, 20–30 mesh.

3.4. *Standard sulfate solution.* Dissolve 1.4787 g Na_2SO_4 in about 500 ml and make to exactly 1 liter. This will have a sulfate concentration of 1,000 mg/l.

4. Procedure

4.1. Measure 50 ml sample into a 250-ml erlenmeyer flask. If the sample contains more than 150 mg/l sulfate, an aliquot should be diluted to about 50 ml. If the sample contains more than 15 mg/l sulfate, add 10 ml buffer solution (I), and if less than 15 mg/l, add 10 ml buffer solution (II). When buffer solution (II) is used, it is essential that a blank be run using buffer solution (II) at the same time as the sample. If the sample is not clear and colorless at this point, the absorbance is measured and recorded. Place the sample on the magnetic stirrer and adjust the speed to a previously determined value such that splashing does not occur and the barium chloride crystals dissolve in more than 10 but less than 30 sec. Add 1 spoonful of barium chloride crystals noting the time to the nearest second. The crystals must be added while the solution is being stirred, and the entire contents of the spoon must be delivered without hesitation, and in such fashion that no crystals adhere to the wall of the flask. Stir for 1 min ±5 sec. Read the absorbance at 5±0.5 min after the barium chloride is added. All samples and standards should be exposed to the heat of the photometer lamp for approximately equal intervals of time.

4.2. Prepare a series of standards from dilution of the standard sulfate solution containing 10–150 mg/l sulfate. Using buffer solution (I), determine the absorbance of these standards as in 4.1. The calibration curve will have a point of inflection so that a relatively large number of standards are required to construct this curve accurately. The shape of the curve will depend upon the optics of the photometer used, so that each analyst should determine by trial the number of points required. The upper end of the curve should be terminated at the absorbance value of 1, or less if the absorbance readings cannot be made accurately on the particular instrument employed. A new curve is required if the photometer lamp is replaced or if any other changes are made in the optical system. The curve so prepared will be valid over a temperature range of 20°–30°C.

5. Calculations

If buffer solution (I) was used, the sulfate concentration is determined directly from the calibration curve after subtracting the absorbance of the sample prior to the addition of barium chloride. If buffer solution (II) was used, the sulfate concentration of the blank must be subtracted from the apparent sulfate concentration as determined above. Because the calibration curve is not a straight line, this is not equivalent to subtracting the absorbance of the blank from the absorbance of the sample.

TABLE 2

Results of Addition of Known Amounts of Sulfate to Tap Water

Sulfate Added mg/l	Sulfate Found mg/l	Sulfate Recovered		Standard Deviation mg/l	Coefficient of Variation
		mg/l	%		
	25.7			0.28	1.09
9.6	35.5	9.8	102.1	0.25	0.70
19.2	44.9	19.2	100.0	0.32	0.71
48.0	74.7	49.0	102.1	0.84	1.12
96.0	122.6	96.9	100.9	1.28	1.04

The correction for absorbance prior to the addition of barium chloride is not exact, and considerable error may be introduced if this absorbance is more than 10 per cent of the absorbance from the barium sulfate precipitate.

If the sample was diluted, the result must be multiplied by the proper dilution factor.

6. Precision and Accuracy

The precision is dependent upon the photometer used, and the accuracy is limited by the difficulty of constructing the calibration curve. Nephelometer readings are not reproducible. Table 2 summarizes the recoveries found by three analysts on samples prepared by adding known amounts of sulfate to tap water. Each result is the average of six determinations, two by each analyst. Although one of the analysts had no previous training in the procedure, there was no significant difference in his results. The precision compares favorably with the best gravimetric work. As expected, the accuracy is not quite as good as the precision.

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Installation of Concrete Water Pipe

Committee Report

A report prepared by Committee 8320 D—Reinforced Concrete Pipe, Ernest W. Whitlock, Chairman. Other members of the committee are: M. K. Socha (Cochairman), L. E. Ayres, L. O. Gardner, M. G. Lockwood, H. F. Peckworth, R. A. Skinner, C. B. Clinger, G. L. Curtis, H. F. Kennison, C. D. Herlihy, S. M. Dore, S. E. Dore Jr., and H. G. Dresser.

Comment and discussion by readers are invited and should be addressed to the Editor of the JOURNAL.

1. Purpose and Scope

THE last 20 years of the 50-year history of the concrete pipe industry have been characterized by a rapid increase in the use of concrete pressure pipe in the water supply field. This trend has been brought about by improvements in design and manufacturing and by the introduction of new types of pipe.

Many persons in the water supply field are not familiar with the various kinds of concrete pressure pipe that are available today and with methods that are in use for handling and installing the pipe. The purpose of this report is to provide descriptions of available concrete pressure pipe and suggestions for installation based on experience in various parts of the United States. The report includes the procedures used in layout, transportation, trenching, installation, backfilling, special construction, field testing, sterilization, and making taps and connections. It is not intended to provide standards or specifications for the design, manufacture, or installation of concrete pressure pipe.

Much of the information contained in this report has been published previously in the form of descriptive articles on specific installations and in instructions published by manufacturers of concrete pressure pipe. The members of AWWA Committee 8320 D—Reinforced Concrete Pipe, however, believe that there is a need for presenting this information in a single document.

2. Description of Concrete Pressure Pipe

The types of concrete pressure pipe now manufactured are relatively new. Their use, however, has increased at a rapid rate in all parts of the United States.

The first reinforced concrete steel cylinder pressure pipeline was a 36-in. diameter line constructed at Cumberland, Md., in 1919. Prestressed concrete steel cylinder pipe was first used for water service in the United States in 1942. Since that time, many millions of feet of the pipe have been manufactured and installed in this country. In the western and southwestern parts of the United States, a type of concrete pressure pipe generally known as pretensioned concrete

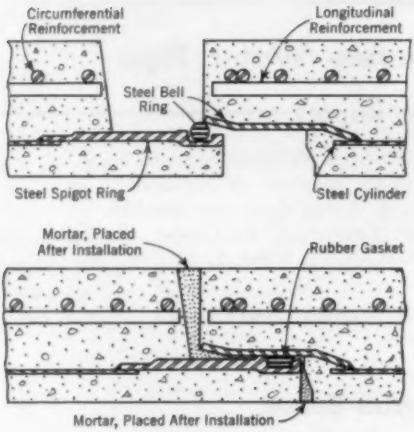

Fig. 1. Cross Section of Nonprestressed Concrete Cylinder Pipe and Joint

The concrete both within and outside the steel cylinder is applied by vertical casting and vibration. Curing is done by means of water or steam. Mortar is placed after installation.

cylinder pipe has been used extensively for a number of years. Another type that has been used, principally for low-pressure lines, is noncylinder concrete pressure pipe that is not prestressed. Within the past 20 years, prestressed concrete pipe that does not contain a cylinder has been developed and used principally outside of the United States.

Nonprestressed Concrete Cylinder Pipe

From 1920 to about 1940, most of the concrete pressure pipe used in the United States by the water supply industry was steel cylinder concrete pipe that was not prestressed. More than 12,000,000 ft of this pipe has been installed to date. It is manufactured in sizes ranging from 2 ft to more than 12 ft in diameter and for working pressures as high as about 260 psi.

Nonprestressed concrete cylinder pipe, as manufactured today, consists of a welded steel sheet or steel plate cylinder with steel joint rings welded to its ends; a reinforcing cage or cages of steel rods or bars surrounding the cylinder; a wall of dense concrete covering the steel cylinder inside and out; and a preformed gasket of rubber for providing the joint seal (Fig. 1). Each steel cylinder, with joint rings attached, is tested hydrostatically for watertightness before it is encased in concrete. Prior to about 1935, a preformed lead gasket, calked from the inside, was used instead of a rubber gasket.

The concrete inside and outside the cylinder is applied by vertical casting and mechanical vibration. Curing is accomplished by means of water or steam. The pipe generally is made

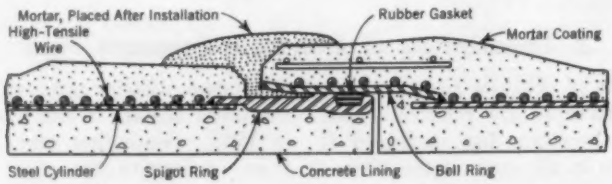

Fig. 2. Lined-Cylinder Prestressed Concrete Pipe and Joint

The cylinder is lined centrifugally with dense concrete, and high-tensile wire is wrapped around the steel cylinder. The wrapped core is then covered with a mortar coating. Joint mortar is placed after installation.

in 12-, 16-, or 20-ft lengths. The circumferential steel of the cage provides about 40–80 per cent of the reinforcement.

Prestressed Concrete Cylinder Pipe

Prestressed concrete cylinder pipe was first produced in the United States in 1942 for the cities of Penniman, Va., and Hyattsville, Md. Because of its many advantages, including low cost of production and excellent performance under various internal pressures and external loading conditions, it has rapidly gained favor with the water supply industry. Since 1942, about 16,000,000 ft of this pipe, 16–120 in. in diameter, has been manufactured in the United States.

generally available with diameters of 24–72 in. and is designed for pressures as high as 350 psi. Pipe with larger diameters has been constructed. Fig. 2 shows a closed section of the joint of a typical lined-cylinder prestressed concrete steel cylinder pipe.

The welded steel cylinder with joint rings attached is made and tested in the same manner as the nonprestressed cylinder pipe. It is then lined centrifugally with dense concrete by a method that rapidly revolves the pipe in a horizontal position. The lined cylinder is cured, and high-tensile wire is wrapped around the core directly on the steel cylinder. The tension of the wire is measured accurately and constantly to produce a predetermined residual compression in the core. Spacing and

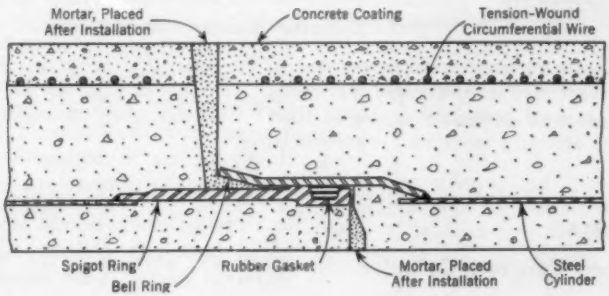

Fig. 3. Embedded-Cylinder Prestressed Concrete Pipe and Joint

In this type of pipe, the tension-wound wire, instead of being wrapped around the steel, is wrapped around a concrete core in which the steel cylinder is embedded.

The two general types of prestressed concrete steel cylinder pipe are: (1) pipe with a steel cylinder lined with a concrete core, and (2) pipe with a steel cylinder embedded in a concrete core. The first or original type is supplied with diameters of 16–48 in. and is designed for pressures as high as 250 psi. The embedded-cylinder type, which was developed later, is

size of wire are determined by design requirements. The wrapped core is then covered by a dense, premixed mortar coating about $\frac{3}{8}$ in. thick, applied by an impact method.

A recent development in prestressed cylinder pipe is the embedded cylinder, a section of which is shown in Fig. 3. The cylinder and joint rings for embedded-cylinder pipe are constructed

in the same manner as for the other types of cylinder pipe. The completed cylinder with joint rings is then embedded in concrete by vertical casting. After the concrete is cured, the wire reinforcement is wound around the outside of the concrete core that contains the cylinder, instead of being wound directly on the cylinder. An exterior coating of premixed mortar is applied by an impact method or by the vertical-casting method. This type of construction has been found to be superior for large-diameter pipe and cement mortar 0.5 in. thick on 16-in. and smaller pipe, and 0.75 in. thick on 18-in. and larger pipe. Reinforcing rods are then wound under measured tension around the lined cylinder. To complete the pipe, a 0.75-in. mortar coating (measured from the rod) is applied by means of mechanical or pneumatic projection.

This type of pipe generally is made with diameters of 10–36 in. and is available with diameters as large as 72 in. The pipe sections are usually 32 ft long and lighter in weight than

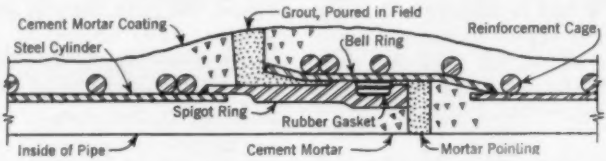

Fig. 4. Pretensioned Concrete Cylinder Pipe and Joint

Although similar to lined-cylinder prestressed concrete pipe (Fig. 2), pretensioned concrete cylinder pipe is lighter and less costly. It is not as rigid as the former kind of pipe and is used primarily in places where it is not likely to undergo extreme external loads.

for pipe designed for comparatively high pressures.

Pretensioned Concrete Cylinder Pipe

Pretensioned concrete cylinder pipe (Fig. 4) is manufactured and used for moderate- and high-pressure service in the western and southwestern parts of the United States. The steel cylinder may be formed as a helically welded tube or as a tube with longitudinal seams. The steel joint rings are attached in the same general manner as for other types of concrete pressure pipe. The steel used for the cylinder is generally heavier, size for size and class for class, than that used for other types of concrete pipe with steel cylinders. The cylinder is lined with vertically cast pipe of the same size.

Pretensioned concrete pipe is a semirigid pipe. It deflects slightly from external loads. Care should be exercised in providing proper bedding and backfill, particularly with sizes greater than 36 in. ID. These are important factors in developing the full external-load carrying capacities of this type of pipe.

Noncylinder Concrete Pipe, Nonprestressed

Noncylinder pipe that is not prestressed has been used extensively in the water supply industry for low-head transmission lines. It generally is not used where internal pressures are greater than about 45 psi. It is made with a rubber and steel joint, although

a similar type of joint with concrete forming the bell and spigot is sometimes used. It is made with either one or more reinforcing cages and with diameters of 12–144 in. Concrete generally is applied centrifugally or by vertical casting. Figure 5 shows a section of this type of pipe with two reinforcing cages and a rubber and steel joint.

Noncylinder Concrete Pipe, Prestressed

Prestressed concrete pressure pipe was first produced commercially in France in 1937. Since that time, this pipe has been manufactured and used with varying degrees of success in a number of places outside the United States. Only a small number of installations of prestressed noncylinder pipe have been made in the United States, including installations made in 1941 and 1943 at Chicago. But some manufacturers in this country have spent much time and effort in research toward development of an acceptable noncylinder prestressed pipe that can be manufactured economically.

Standards for Concrete Pressure Pipe

In April 1943, the AWWA Board of Directors authorized the preparation of "Tentative Emergency Specifications for Reinforced Concrete Pressure Pipe."[1] These pertained to a number of different types of pipe. The specifications served a useful purpose during the war years but are now obsolete.

Since AWWA Committee 8320 D—Reinforced Concrete Pipe was formed in 1946, it has prepared standards for four types of concrete pressure pipe. These standards have been revised from time to time to conform to current changes in available materials and to improvements in manufacture.

Reinforced concrete pressure pipe, pertaining to steel cylinder pipe that is not prestressed, is covered by AWWA Standard C300.[2] Both lined-cylinder and embedded-cylinder types of prestressed concrete steel cylinder pressure pipe are dealt with in AWWA Standard C301.[3] Noncylinder concrete pressure pipe that is not prestressed is covered by AWWA Standard C302[4] and ASTM Specification C-361.[5] Pretensioned concrete pressure pipe with steel cylinder is covered by Federal Specification SS-P-381.[6] The use of noncylinder prestressed concrete pipe in the United States is not yet great enough to justify the preparation of a standard.

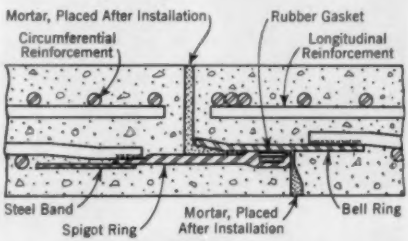

Fig. 5. Noncylinder Nonprestressed Concrete Pipe and Joint

The pipe shown has two reinforcing cages, although the number of cages may vary. The joint may also be formed by a concrete bell and spigot, but the use of steel is more common.

Pipe Joints and Fittings

Rubber-and-steel joints. Since 1934, rubber-and-steel joints have been used almost exclusively for concrete pressure pipe with steel cylinder. This joint consists of a flat bell ring and a specially shaped spigot ring with a rectangular groove. A stretched rubber ring gasket with a round cross

section of proper size is placed in the groove. When the spigot is entered into the bell, the gasket is compressed between the steel surfaces of the bell and spigot, providing a watertight seal that remains tight and permits movement in the joint. The gasket is confined on all four sides and is compressed. Many tests and years of successful experience have demonstrated its suitability for concrete pressure pipe.

Fig. 6. Use of Tee Fitting

Shown is a 60×60-in. tee. A cloth diaper used when pouring mortar to seal the joint (see also Fig. 17, Sec. 6) can be seen on the branch of the tee, to the left of the pipe opening. In the background is another tee with a smaller branch.

Several variations of this type of joint have been developed. A steel sleeve double-rubber-gasket joint has been used extensively for low-pressure noncylinder pressure pipe. In this design, the pipe is made with two spigot ends, each containing a rectangular groove in the concrete near the ends. A steel sleeve, long enough to cover the gasket on the next pipe, is placed on the gasket at one end. The sleeve is covered with reinforced mortar at the plant and forms a bell. The field joint is made up in a manner similar to that for the steel-and-rubber joint described before. Other forms of confined round-rubber-gasket joints that do not use a steel bell ring have been developed and used with low-pressure noncylinder concrete pipe.

Bevels and bends for straight pipe. At present, most types of concrete pressure pipe are made in lengths of 16 ft. Pretensioned pipe generally is manufactured in lengths of 32 ft. In straight pipe, joint openings from 0.5 in. for 16-in. pipe to 1.5 in. for 144-in. pipe are normally recommended. This permits the layout of long-radius curves with straight pipe. Bevel pipe is made by placing one of the joint rings at an angle on the end of a full length of pipe. A full bevel provides a deflection of about 4–5 deg, depending on the manufacturer and the size of the pipe. Bevels for lesser deflections are available in accordance with an individual manufacturer's practice. Bevel adapters are short pieces made by welding beveled bell-and-spigot joint rings together. They are very useful in obtaining necessary deflections to meet unforeseen field conditions. Most manufacturers provide tables showing laying lengths and deflections for standard bevel pipe and adapters. These tables facilitate making and checking schedules for laying concrete pipe.

Specials. Two types of special fittings are usually made for closures, bends, branches, manholes, and connections to other pipe. Type A in-

cludes specials of the same general type as steel cylinder straight pipe. It is made with a steel cylinder, concrete or mortar lining, and a cage-reinforced concrete exterior covering. Type B specials are made of cut and welded steel plate with wire-mesh-reinforced mortar coating on the interior and exterior. Both types are included in AWWA Standards C300, C301, and C302.[2-4]

Other fittings. Other concrete pipe fittings commonly used and manufactured as standard fittings by most manufacturers are adapters for connecting concrete pipe to other pipe, reducers, outlets, tees (Fig. 6) and crosses, wyes, air valve and service connections, blowoff assemblies, manholes, closures, bulkheads, and caps.

Subaqueous Concrete Pipe

Pipe designed for underwater installation is made in the steel cylinder and noncylinder types by most manufacturers of concrete pressure pipe. Although the specific joint design may vary considerably, a confined rubber gasket to provide the watertight seal is relied on for most subaqueous pipe joints. The actual joint may be the conventional steel bell-and-spigot joint or some other type, such as cast-iron bell and spigot, an all-concrete joint, or a joint utilizing a glass-reinforced plastic sleeve. When pipe is preassembled before laying, two types of joint are sometimes used, one for preassembly and another for underwater connections.

Heavy, metal anchor sockets are often attached to the ends of subaqueous pipe at each spring line. Lugs that anchor to the sockets receive draw bolts that are used by divers to draw the bell and spigot together and make up the joint. After installation, the bolting, which is temporary, should be loosened in order to permit normal settling and joint movement.

Subaqueous concrete pipe can be varied considerably to meet special job requirements. For example, it may be made sufficiently heavy to permit dewatering, if so required by the purchaser.

3. Layout of Pipelines

Many of the procedures discussed herein apply to the preparation of contract drawings for major pipeline projects, regardless of the type of pipe to be installed. The procedures represent good practice for such projects. Lines of small diameter and short sections of distribution lines can often be installed satisfactorily from a relatively simple drawing based on a minimum amount of preliminary field work.

Surveys

A thorough reconnaissance survey of the several most probable routes for the pipe will decrease the number of routes that will require more thorough investigation. The size and operating space requirements of equipment, condition of streets, intensity of traffic, number of parking facilities, density of trees, and presence of overhead lines should be considered. Photographs of the pertinent areas are useful and time saving.

In builtup areas, detailed research of the substructure, by use of public records or records of companies maintaining substructures in the streets, will serve to narrow the number of alter-

nate routes to be considered. A check should also be made to determine whether future projects have been planned for the areas being surveyed, especially projects involving sewers and storm drains or other nonpressure hydraulic structures. Whenever cracks in pavement are noted, original street plans or contour maps of the area should be studied to determine if fill ground, swamp areas, and other conditions pointing to unstable foundations exist. Test holes should be drilled to determine underground conditions, for knowledge of these conditions is necessary before pipe can be designed and costs estimated.

Surveys to establish accurately the horizontal alignment and profile along a proposed pipeline route, with adequate cross sections utilized where necessary, should be made on all portions of the route. When data from other sources are used, survey ties should be checked. Traverses should be closed for horizontal control, and bench marks should be checked for vertical control. It may be convenient to check major substructures at the same time. Concrete pipelines are usually tailor-made at the plant to fit the plan and profile. Therefore, variance between recorded and existing distances, either vertical or horizontal, may cause difficulties and expense during construction. A supply of random short lengths of pipe and bevel adapters will provide flexibility to meet unexpected conditions in the field.

Contract Drawings

The plan and profile, based on the field surveys, will provide the necessary data for establishing the line and grade of the pipeline and the location of bends, anchor blocks, cradles, manholes, vaults, and blowoffs. The location of these appurtenances should be shown by station and elevation in feet on the plan and profile and on the detail contract drawings. The profile and plans should show the alignment and elevation of pipe and the grades between points; the size, class, and description of the pipe to be installed; and the location, elevation, and description of appurtenant structures.

Information for Manufacturer

The manufacturer generally is furnished with plans and profiles of the pipeline, showing alignment and grade of the area along the pipe route; the location of all outlets, connections, and special appurtenances; the design head or the required cross-sectional area of effective circumferential reinforcement per foot of pipe wall for each portion of the pipeline; and specific, special details that are necessary to aid the manufacturer to produce the pipe and fittings that will do the job. By indicating the fittings or outlets that may be located a few feet on either side of the position shown on the profile, one may effect considerable economy of installation.

The extent of information supplied to the manufacturer varies considerably. Usually, the manufacturer is required to provide a detailed layout schedule that is checked and approved by the owner's engineer before the pipe is manufactured.

Pipe Cover

Cover on large-diameter pipelines depends on climatic conditions and clearance for existing substructures. The minimum cover is usually 3 ft.

Most standard concrete pipe designs will withstand 5–6 ft of cover, and often considerably more, together with traffic loads. When external load conditions require them, heavier designs should be provided.

Curves, Bends, and Branches

Pipe with rubber gasket joints can be laid along a curved alignment if the joints are opened 0.5–1.5 in., depending on pipe size. Curves of short radius are attained when the spigot ring is attached to the cylinder at an angle as large as about 5 deg. Sharper changes in grade and alignment are made with bends. It is good practice to combine horizontal and vertical deflections in a single bend, but not with bevels or opened joints.

Manholes and Openings

Manholes are sometimes installed on both sides of line valves and adjacent to line closures. Others may be required near major branches or at other points, so that inspection of the line will be facilitated after it is in service.

Blowoffs and Pumpouts

Blowoffs are located at the low points in the line and should be of sufficient size to dewater the line in a reasonable period of time. Locating the outlet near the bottom of the pipe not only permits the pipe to drain dry but also facilitates cleaning of the pipe by flushing. Pumpouts are sometimes used at minor sags in the pipeline and consist of an opening of sufficient size in the top of the pipe to accommodate a pneumatic pump, together with air lines and discharge hoses.

Air and Vacuum Valve Connections

Either automatic or hand-operated air-release valves are provided at high points in a line to release air during the initial filling of the line and during subsequent operation. Generally, automatic air valves are provided only at the highest points, and a corporation cock or other small valve is used at other high points. Vacuum valves are also needed on certain pipelines to permit air to enter the line, thus preventing secondary water hammer when there is a downsurge following disruption of flow.

The determination of the location, size, and type of air-release valves and vacuum valves is one of individual study, based on the pipeline profile, operating conditions, and structural characteristics of the pipe.

Closures and Connections

Closure pieces are available for connecting two sections of pipeline in the field. Some of these are made so that the closure piece can be removed readily and replaced later to permit removal or insertion of a valve or fitting.

Connections to existing pipe constructed of material other than concrete are made by various types of adapters. Adequate, detailed information concerning the existing pipe should be furnished to the manufacturer to insure proper fit of the adapter. Outlets of various types and sizes for future connections can be provided as part of the manufactured pipe. Unanticipated outlets can be tapped into the line under pressure, as outlined in Section 10.

4. Transportation of Pipe

Concrete pressure pipe is seldom made for stock. For this reason, curing and storage yards of most manufacturers have space available only for a few weeks' storage after pipe curing is completed. There is mutual benefit to the user and the manufacturer in having deliveries coordinated so that pipe, when ready, can be delivered immediately to the job site. Prolonged storage in the manufacturer's yard or at a location at the job site is uneconomical.

Completed pipe is stored vertically or horizontally on skids or on the ground, if the pipe is of the type and size that can be rolled manually. Otherwise, it should be carried by crane, fork-lift truck, or other suitable equipment. Pipe may be rolled or lifted into loading position. Certain types and sizes of pipe may sometimes be double decked or even triple decked when storage facilities are overtaxed. But the manufacturer's advice and guidance should be requested before multiple-level storage is attempted.

Fig. 7. Hauling of Pipe

Transportation by truck affords a better opportunity for getting pipe to the point of intallation.

Hauling

Concrete pressure pipe generally is transported from the manufacturing yard to the area of installation either by flat-bed trucks or railway cars. The method of hauling depends on economic considerations, primarily based on the distance involved, comparative shipping costs, and the facilities available for getting pipe to the job site. Truck transportation affords a better opportunity for getting pipe to

the point of installation (Fig. 7). Most manufacturers offer delivery to points along the trench that are accessible to trucks and trailers operating under their own power.

Truck transportation is controlled by state highway restrictions with regard to weight, width, and height of loads. Generally speaking, the tractor-trailer type of equipment is adaptable under most state regulations to provide for the hauling of loads as heavy as 20 tons and as wide as 8 ft. The height of the load is governed by overhead-clearance restrictions along the route. In spite of state restrictions, pipe loads in excess of the foregoing general weight and width restrictions generally may be hauled under special permits that can be obtained if the vehicle design provides for adequate distribution of weight on the roadways.

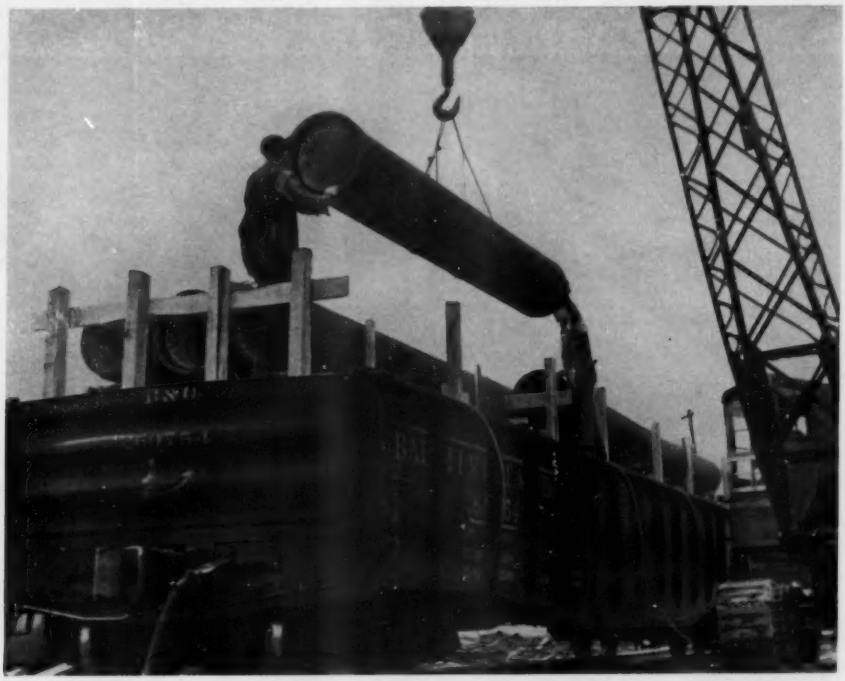

Fig. 8. Loading of Pipe

Railway shipments of pipe require more extensive blocking to avoid damage than is required for truck hauls.

Transportation by railway is also limited by weight and clearance restrictions. Generally, cars 50 ft long are used for railway delivery. Gondola cars can be used instead of flat cars when pipe is of the size and type that allow for multiple-level stacking. The normal capacity of gondola cars,

for example, is 45 sections of 16-in. pipe in 16-ft lengths, and 3 sections of 48–78-in. pipe in 16-ft lengths.

Loading

Pipe-loading procedures vary according to the type of pipe involved, the handling method used, and the type of vehicle to be loaded. Flat-bed vehicles permit side loading and unloading. Where loading ramps of vehicle height are available, pipe is rolled directly from storage skids onto the carrier. Where ramps are not available, pipe can be winched onto the carrier by use of timbers or heavy-duty skids inclined from ground level to the carrier bed, or a crane or fork-lift truck can be employed.

Close attention must be given to adequate blocking and bracing of pipe on the carrier (Fig. 8). All loads must be secured against lengthwise or lateral movement. Multiple-level loads may be braced with timbers, wooden cradles, sand bags, or old rubber tire "cushions" between pipe layers. These loads must be secured with chains and load binders located over the common points of bearing between pipe layers. Railway shipments require more extensive blocking than is required for truck hauls.

Fig. 9. Unloading With Skids and Winch

Skids and winch are desirable for unloading pipe because they are mobile and easy to use, especially with large-diameter pipe.

Delivery and Unloading

Prior to the shipment of pipe, it is important that the supplier and purchaser agree on a definite delivery location. These locations may be f.o.b. carrier at the manufacturer's plant or at points of delivery. Trenchside delivery may specify unloading and stringing of pipe either by the supplier or by the purchaser. In any event, the supplier is responsible for furnishing pipe in good condition in accordance with the delivery terms. It is the purchaser's responsibility to inspect

shipments at points of delivery and accept such shipments or reject pipe damaged in shipment. The handling of pipe beyond the agreed point of delivery is the purchaser's responsibility.

On truck hauls, when pipe is not double decked, skids and a winch are desirable because they are mobile and easy to use, permitting pipe to be rolled directly to the ground (Fig. 9). They

Fig. 10. Seating Pipe With "Pipemobile"

Concrete pipe sections 13.5 ft in diameter, 16 ft long, and weighing 68 tons were handled by a self-propelled rig called the "Pipemobile." The photograph shows pipe being carried from storage area to trench.

The equipment for unloading concrete pressure pipe varies with the method of transportation and the facilities at the destination. Also to be considered is whether the pipe has to be unloaded at a siding, strung along the ditch line, or stockpiled.

are particularly desirable for handling large-diameter pipe—84 in. or larger—when the pipe weight may exceed 15 tons. Other equipment capable of handling this weight is quite cumbersome to move about when arrival schedules are erratic, particularly if

shipment is made by truck or if there is no central unloading point. Special equipment can be designed for handling large-diameter pipe; one example of such equipment is the "Pipemobile," used to assemble the siphons for the Colorado River Aqueduct (Fig. 10).

With a few exceptions, cranes of the proper capacity using steel cable, belt slings, or specially designed devices can load or unload any size of pipe regardless of the means of transportation. Fork-lift trucks having sufficient capacity can unload pipe from most carriers if the carrier location is accessible and if terrain conditions are suitable for lift-truck operation. The uprights of the forks should be covered with wood or rubber in order to cushion the pipe against shock and prevent damage to the exterior of the pipe.

Although concrete pipe is an exceptionally rugged product, reasonable care should be exercised to prevent bumping pipe and causing possible damage to pipe ends.

5. Trenching

Ample rights of way will help speed pipeline construction and reduce costs. A right of way should be large enough to accommodate vehicles delivering pipe and have sufficient additional width to allow for the stringing of pipe. In addition, there must be space for pipe-laying equipment and trenching operations on the working side of the trench. The spoil bank should preferably be placed on the opposite side of the trench; but, in some instances of narrow rights of way, it may be feasible to spread the soil material on the operating side of the trench and operate the pipe installation equipment on top of the spoil area.

With narrow rights of way, a 20-ft construction easement may be necessary for access. In narrow city streets, all material may have to be hauled and pipe brought in section by section.

Line and Grade

The pipeline should be so aligned within the right of way that it will provide most effectually for the installation of parallel pipelines, if it seems that a parallel line may be needed in the future. Concrete pressure pipe serves best when it is buried in the ground. A nominal cover of 3–5 ft over the top of the pipeline is recommended. Considerably greater depths often are necessary and can be provided for in the design and bedding of the pipe. Moderate depths, however, will result in savings in pipe design and installation costs.

Care should be taken in the field in placing proper offset line and grade stakes that will permit accurate excavation of trench to line and grade. This is desirable in order to insure proper installation when pipe and special fittings are manufactured to coincide with the detailed layout schedules. Nevertheless, minor changes in line and grade, as well as other adjustments, can be made during installation.

Trenching Equipment

The trench-excavating equipment used varies with soil conditions, trench depth, terrain, and the contractor's preference for, or the availability of, certain machines. The more common types of equipment used are backhoe shovels, trenching machines, draglines, power shovels, and scoop shovels. Backhoe shovels are used extensively.

Pipe with diameters less than 72 in. can be installed by a backhoe, without additional equipment. If other excavating equipment is used, a crane, sideboom tractor, or other special machinery is employed in installing the pipe. Where a backhoe is impractical or unavailable, the ditch may be dug by other means, the pipe lowered by a crane, and the joint pulled together by chain hoist, ratchet hoist, or winch. Economical trenching operations depend on the use of proper equipment.

Trench Excavation

Regardless of the type of excavating equipment used, the trench first should be dug to approximate grade, with an allowance for sufficient width to permit proper tamping of backfill around the pipe. When a backhoe is used, the trench excavated at one time should be no more than that required to accommodate one length of pipe clear of the pipe already installed (Fig. 11). With other excavating equipment, the excavation of the

Fig. 11. Trench Excavation With Backhoe

When a backhoe is used for trenching and laying, the trench excavated at one time should be no more than that required to accommodate one length of pipe clear of the pipe already installed. The operations in the trench shown are the joining and alignment of a 16-ft length of 42-in. concrete pressure pipe.

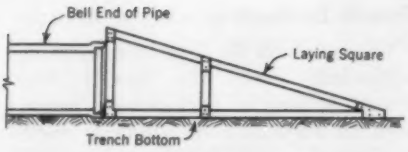

Fig. 12. Laying Square

The short leg of the square is fitted tight against the bell end of the installed pipe section. The long leg provides a guide for making proper grade on the trench bottom for the next section to be installed.

trench and the laying of pipe are two independent operations that need not be in close sequence.

Rough grade should be made with excavation equipment, with grade and alignment strings or boards used as a guide. Final grade should be made by hand to insure uniform bedding so that the bottom of the pipe will rest on the undisturbed bottom of the trench throughout the length of each pipe. Grade and line for pipe can be maintained and checked by use of the combination grade and alignment board when an offset traverse or grade line is provided. To assist in preparing final grade, a wooden grade or laying square may be used (Fig. 12). The long leg of the square is equal to the length of the pipe; the short leg is equal to the pipe's outer diameter. A cleat on the short leg of the square fits within the bell of the pipe. By butting the short leg of the square vertically against the end of the pipe already laid, with the cleat set within the bell, a close guide for making grade on the bottom of the trench will be provided by the bottom surface of the long leg.

A second method of checking the elevation of the final grade is by use of a stringline set on batter boards placed across the trench. The elevation of the batter boards is determined directly from the offset stakes; the distance from the stringline to the bottom of the trench is measured with a straight wooden pole.

Another method involves the use of a grade and alignment square, an inverted L device with a liquid level gage on the vertical and horizontal arms (Fig. 13). The horizontal arm on this device is extended to a stringline between the offset stakes adjacent to the trench. The vertical arm is extended to measure the required depth at any position along the trench.

When the final grade is made, a small groove should be dug in the trench bottom at the location of the midpoint of the pipe to be installed. This groove in the subgrade will facilitate the removal of the cable sling from the pipe after it is laid. At a point corresponding to the end of the pipe to be installed, another groove in the subgrade should be made for pipe with extended bells. This groove will facilitate the placement of a cloth or reinforced paper diaper around the bell end of the pipe. The diaper will be used when the external mortar joint is poured (see Sec. 6).

Wherever practicable, the minimum width of the trench at the top of the pipe should be equal to the outside

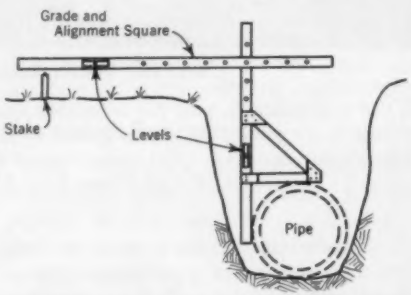

Fig. 13. Grade and Alignment Square

That the pipe is properly positioned at any point in the trench can be checked by use of the grade and alignment square.

diameter of the pipe plus 18 in. The maximum width of the trench should be equal to the outside diameter of the pipe plus 24 in., unless approved otherwise by the engineer. The sides of the trench should be vertical, at least to the top of the pipe. Wherever necessary to prevent cave-in, an excavation should be adequately sheeted and braced. Where sheeting and bracing are used, the trench width must be increased accordingly. Trench sheetting should remain in place until the pipe has been laid and the earth around it compacted to a depth of 2 ft over the top of the pipe.

Sometimes it is difficult or impractical to obtain a satisfactory, uniform bearing for the pipe because the subgrade is rock, unyielding shale, or marl, or because there is muck on the trench bottom. If such conditions exist, the contractor should, as directed by the engineer, excavate to a depth of not less than 4 in. below the normal subgrade, and provide either a sand or gravel cushion. When extreme depths of cover are unavoidable, a concrete cradle for the purpose of bedding and supporting the pipe may be required.

Where ground water is encountered, it must be removed with pumps or by other means, so that the necessary work can be accomplished under relatively dry conditions. Pumps of ample capacity, in duplicate, should be provided to insure that once the trench is made dry, it can be kept dry until the portion of the pipeline involved is completed. Often, well point systems must be installed to lower the ground water table and to provide satisfactory conditions for pipe installation. When the trench cannot be dewatered, the use of an insoluble gasket lubricant will permit the laying of pipe in water.

Pavement and Obstructions

In street work, pavements must be broken carefully in order to avoid unnecessary damage to installations and, consequently, excessive costs of replacement. Some breakage may be avoided by the use of such special equipment as saws with abrasive blades. Great care should be exercised in locating water mains, sewers, telephone conduits, gas mains, and other types of substructures. Explorations ahead of trenching work will often help prevent serious damage to these structures. The problem of adequate protection for existing underground installations is a serious one and expensive to solve, particularly when large-diameter pipe is installed.

6. Laying of Pipe

Pipe laying may be accomplished with different types of installation equipment, depending on the diameter and length of the pipe sections involved. The equipment used includes the backhoe, crawler crane, truck-mounted crane, and tractor with side-boom attachment.

Installation With Backhoe

In laying pipe with a "pull shovel" or backhoe, a short cable terminating in a double laying hook should be attached to the back of the bucket. A short sling is then placed around the midpoint of the pipe, and the ends of the sling are looped over the double laying hook. If the pipe is properly balanced, it is ready to be picked up and lowered into the ditch (Fig. 14). The spigot ring of each pipe, and especially the groove, should be thoroughly cleaned and wire brushed before the pipe is lowered into the trench.

While a section of pipe is being slung and picked up, a reinforced paper

or cloth diaper band may be placed around the bell of the pipe section already in place. From this position, the diaper readily can be slipped over the joint recess when the next pipe has been placed properly.

When a pipe section has been lowered so that the spigot is within reach of a man standing on the pipe already in place, a rubber gasket is placed in the spigot groove. The gasket must first be thoroughly lubricated with a vegetable compound soap. It is desirable also to lubricate the spigot groove to insure that the stretched gasket will distribute itself uniformly when it is seated in the groove. When the gasket is stretched, care should be taken to maintain uniform tension on the rubber around the entire circumference of the spigot. Meanwhile, the bell of the pipe already in place should be carefully cleaned and lubricated with vegetable soap. When the pipe is large enough to be entered, the bell should be cleaned from within the pipe already laid. From there, the workman can perform the operation safely, and, at the same time, he will be in a position to assist in guiding the next

Fig. 14. Laying Pipe With Backhoe

Pipe is laid with the same machine used for excavating the trench. Shown is a section of concrete pressure pipe, 54 in. in diameter, being laid during the installation of a feeder main.

length of pipe into the bell and to check the joint from within.

After the pipe has been lowered into the trench, it is desirable that three men guide the spigot into the bell—a man on top of the pipe previously laid, a man within this pipe, and a man at the bell end of the pipe being laid. If the pipe is too small to admit a man, it will be sufficiently light to be handled by one man at each end.

Once the spigot has been correctly aligned within the bell, the operator can manipulate the backhoe to get sufficient power to push the pipe home. If, as occasionally occurs, the joint is unusually difficult to push home, additional thrust may be obtained by lowering the pipe to the bottom of the ditch and moving the cable sling closer to the bell end. The pipe can then be pushed home. In a short time, a capable operator will learn to position his machine so that sufficient power will always be available to make a satisfactory joint. It should be noted that a thoroughly lubricated joint will go together with much less effort than one improperly lubricated. Care should be exercised to insure that the spigot enters the bell straight and not at an angle. If minor changes are required in grade or alignment, the spigot should be brought straight home, the deflection made, and the gasket checked.

With pipe of sufficient size to admit a man, the workman who has assisted in guiding the pipe home from within the pipe already in place should make use of temporary steel or wooden inserts to prevent the pipe from going completely home. The inserts, placed between the tip of the spigot and the seat of the bell, provide a space for inserting a feeler gage. This gage is used to determine the position of the rubber gasket on the spigot (Fig. 15). If the gasket is in its proper position in the groove, it will be possible to feel it with the tip of the gage around the entire circumference of the joint. Special attention should be given to the section of the gasket in the bottom half of the pipe, for this part of the gasket cannot be observed from outside the pipe. If the gasket cannot be felt all around, the pipe should be withdrawn and the gasket examined for

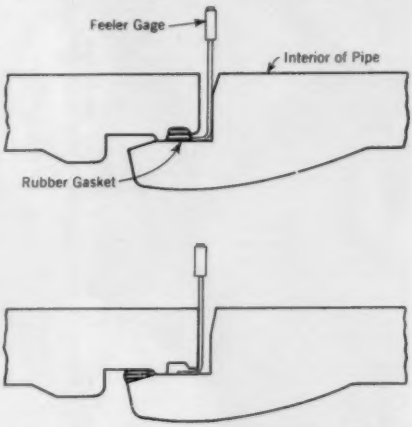

Fig. 15. Feeler Gage for Checking Gasket

When the gasket is in place, as in the upper diagram, the rubber can be felt with the tip of the gage. When the gasket is out of place, as in the lower diagram, the rubber cannot be felt, and the pipe should be relaid.

cuts. If the gasket is not damaged, it may be reused. In all instances, the bell ring and the gasket should be lubricated again with soap before the pipe is relaid.

Once it is determined that the gasket is in its proper position and the pipe properly laid, the joint spacers should be removed and the pipe pushed completely home. If the feeler gage was used carefully, there should be no reason for an unsatisfactory joint. The

correct use of the feeler gage at every joint will eliminate expensive repairs at a later date. When the pipe is too small to admit a man, the proper position of the gasket can be determined from outside the pipe, as the lower half of small-diameter pipe can be reached easily by hand.

Fig. 16. Installation With "Deadman" and Chain Hoist

A cable between a strongback across the bell of the pipe and a "deadman" (pole in foreground) is hooked to a chain hoist. By taking up on the hoist, the workmen can pull the pipe into place.

Installation With Crane

Pipe can also be installed with a crane, side-boom tractor, or other hoisting equipment of sufficient mobility and capacity. The pipe may be lowered and the spigot entered into the flare of the bell in the same manner described before for installation with a backhoe.

Fig. 17. Completion of Joint

Grout was poured beneath the cloth diaper covering the joint of this 96-in.-diameter pipe to fill the exterior recess around the pipe. The top part of the joint was finished off by hand. To the left of the grout pail is the cinching device used to band the diaper to the pipe.

To pull the pipe home (particularly pipe with large diameter), a deadman should be set in the pipe—at least one length, and preferably three lengths, behind the last pipe laid. A strongback is then placed across the bell of the pipe being laid. Cables between the strongback and the deadman are hooked to a chain hoist or ratchet hoist within the pipe, and the hoist is used to pull the pipe into place (Fig. 16).

If instead of a chain hoist or ratchet hoist a winch is used, it may be anchored in a joint recess behind a pipe section previously installed. The cable from the winch may be attached to the bell of the pipe to be installed, either by a pair of hooks or by a strongback across the bell of the pipe. All other operations required for pulling the joint home and checking the gasket are described in the foregoing section dealing with installation with a backhoe and should be followed in detail.

When pipe with a diameter too small to admit a man is laid with a crane, operations up to the point where the spigot is guided into the bell will be the same as those with large-diameter pipe. To pull the joint home when small-diameter pipe is laid, a cable should be left around the barrel of the pipe section last installed. This cable should be joined to the cable sling of the pipe being installed with a chain hoist or ratchet hoist. When the hoist is raised, the pipe is pulled home. As it is impossible to check joints of small-diameter pipe from inside the pipe, particular care should be taken, as described previously, to check the gasket from the outside.

Installation With Side-Boom Tractor

When pipe is laid with a side-boom tractor, operations up to the point of guiding the spigot into the bell are the same as those employed when pipe is laid with a backhoe or crane. After the spigot is guided into the bell, the pipe is lowered to the bottom of the trench, and the tractor is moved back alongside the pipe previously laid. From this position, with the boom

lowered to the top of the trench, the tractor can pull the pipe home with the load line. The distance that the tractor must be moved depends on the size of the pipe and depth of the trench, because the pull must be applied as low as possible along the centerline of the pipe. This method eliminates the need for a sling around pipe previously laid and for chain or ratchet hoists.

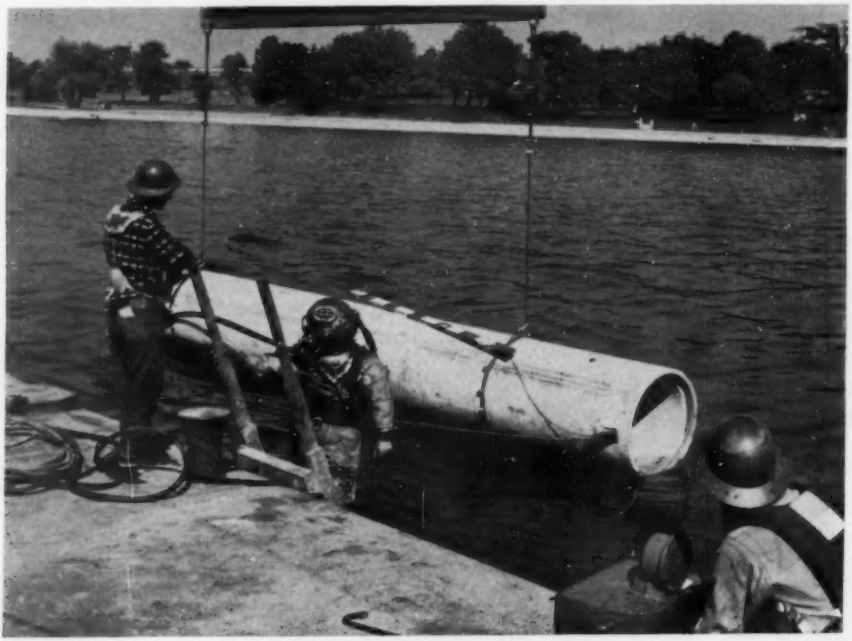

Fig. 18. Installation of Subaqueous Pipe

Shown is a section of pressure pipe, 36 in. in diameter, used in the installation of a 2,500-lin ft intake. The pipe was lifted with a double-bridle sling placed 4–6 ft from each end.

Joint Protection

After the pipe is in place, the reinforced paper band or front wire of the cloth diaper band should be slipped forward to cover the joint recess and wired or strapped in position before the backfill is placed. Both the paper and cloth bands are effective in keeping out dirt and serve as forms for subsequent grouting of the joint (Fig. 17). The outer joint recess should be filled with liquid grout composed of one part cement and two parts sand. The grout is poured beneath the band of reinforced paper or cloth at the top of the pipe and allowed to run down to the underside of the pipe until it completely fills the recess around the pipe. The grout should be "rodded" or "puddled" to insure complete filling of the recess. Before the trench is backfilled, all exposed steel fittings should be protected in the field with

a minimum 1-in. layer of concrete. All steel flanges should be protected with coal tar or other material.

If the pipe diameter is large enough to admit a man, the inside joint recess should be filled with a stiff mixture of mortar and finished off smooth with the inside surface of the pipe after the backfilling has been completed. If calked joints are specified, they should be made of mortar of dry consistency applied in layers, each layer being calked to dense compaction. All excess mortar should be removed from the bottom of the pipe.

Installation of Special Fittings

Elbows are generally installed in this manner: a strongback, deadman, cable, and two bolts are placed in the elbow and the previously laid pipe in order to pull the elbow home. One cable, hooked to a bolt at each end of the strongback, keeps the elbow straight as it is being pulled home. An alternate method employing a chain or ratchet hoist to make the joint can be used. Two hoists should be used to keep the elbow straight. The advantage in using the alternate method is that the elbow can be held in place by the hoists while the next pipe section is being laid.

When pipe is laid in city streets, an obstruction frequently necessitates a quick realignment of the pipeline. Bevel adapters or elbows may be used to change the alignment. A few pipe sections of various short lengths can also be useful when pipe is installed in areas where obstructions are expected.

In addition to the more common fittings, adapters and reducers are provided for installing mainline valves with ends for other pipe. Where calked joints are required, they can be made with cement or lead. As concrete pipe cannot be cut in the field, closure sections are provided, if required, to joint the new line to an existing line.

Installation of Subaqueous Pipe

For the installation of subaqueous pipe, the preparation of the subgrade is dependent on the type of bottom and its depth below the water surface. For soft, mucky material in shallow water, pile bents are preferred. There should be only one pile bent per pipe length situated 3–4 ft behind the flexible joint. With solid material, including rock in either shallow or deep water, timber or concrete sills should be used. Concrete sills should have an embedded timber so that shimming wedges can be attached with spikes. Only one sill per pipe length is required.

A derrick scow or crane on a barge capable of handling pipe is needed for the installation. The pipe is lifted with a double-bridle sling placed 4–6 ft from each end (Fig. 18). Care should be taken to insure that the harness lugs are on the horizontal centerline of the pipe. A spirit level laid across the ends of the pipe in a direct line with the lugs is generally used. This technique insures against misalignment when two sections of pipe are connected with draw bolts. Before the gasket is placed in the annular groove on the spigot ring, it is coated with a water-resistant vegetable soap. Surfaces of both the bell and the spigot rings are similarly coated with lubricant. Normally with large-diameter pipe, two divers direct the positioning of the pipe under water, so that the mouth of the bell joint ring of the pipe being laid is brought around the spigot of the pipe already in place. Each diver then places a draw bolt through the adjacent lugs on his side of the pipe. The bolts are pointed in oppo-

site directions, so that after the diver starts the nut on the bolt he can use a ratchet wrench. The wrench can be operated by men above water with the use of a tie line. After the joint is inspected by divers, nuts are backed off 0.25 in. to allow for flexing of the joint. Wooden 12×12-in. blocks are then wedged under each side of the pipe and spiked to the cross member to prevent lateral movement of the pipe during the backfilling operation.

Care should be taken to deposit the backfill uniformly on each side of the pipe. When this is done, the pipe will be supported evenly throughout its length and not be pushed off the sills or bents by the weight of backfill.

7. Bedding and Backfilling

The bedding of a pipe has an appreciable effect on its external-load carrying capacity. The quality of bedding required is a function of many factors, including the type of pipe, depth of cover, width of trench, and live loads. Furthermore, the bedding used is related to the preparation of the trench bottom prior to pipe installation and the type of backfill and its placement.

Most concrete pipelines are installed in a flat-bottom trench, with the backfill compacted by tamping or consolidated by flooding up to the springline. For the more flexible, pretensioned concrete pipe, the backfill is normally consolidated or compacted to at least 1 ft over the top of the pipe. In any case, the backfill material should be free of boulders and large masses of earth until the pipe is covered with at least 1 ft of earth. The remainder of the backfill can be completed with less attention given to compaction, unless it is required in places such as highway crossings.

At the end of laying operations each day, the open ends of the pipeline should be closed to keep out dirt and animals. A "nightcap" consisting of a bell or spigot ring with a light-gage steel sheet welded to its back may be used for this purpose. A satisfactory half-moon bulkhead to be wedged inside the pipe can be fabricated of wood for the same purpose.

If the steps described above are carefully followed, there should be no incorrectly laid joints and no need for repairs. As the joints themselves are self-sealing and immediately watertight—if laid correctly—it is general practice to backfill immediately after the pipe is laid. This practice not only eliminates the danger of an open ditch but also eliminates the expense of maintaining the ditch and the hazards resulting from traffic tie-ups in populous areas. It also permits the contractor who installs the pipe to keep most of the work concentrated in a limited area for more economical and efficient supervision.

8. Special Construction

Unbalanced forces sufficient to require anchorage or thrust blocks generally occur at changes in alignment and grade, at connections with valve chambers and pumping stations, at plugged connections, and at ends of pipe. The details of anchorages and thrust blocks are individual design problems that depend on many factors.

Thrust Blocks and Anchorage

Anchorage and blocking may be provided in many ways. Most common among these are the use of con-

crete blocks or encasements and structural bracing, as well as the fastening of pipe joints together by harnessing them with bolts and rods or by welding steel joint rings together. When concrete anchors, thrust blocks, and encasements are used, particular care must be taken to insure that the concrete will have adequate bearing on undisturbed soil that will not be disturbed in the future (Fig. 19).

Tied joints are used often to prevent the movement of fittings. Joints may be tied or harnessed by several methods. Some require that the force be transmitted through the steel cylinder of each pipe. Other methods require that the load be carried by steel bars embedded in the concrete wall.

Welded-tied joints for cylinder pipe are often the most economical in overall cost and will provide adequate anchorage. The bell and spigot rings are joined by laying in filler rods and welding them to the joint rings around the entire pipe circumference. A welded-tied joint that retains some joint flexibility has recently been developed. A wedge-shaped ring that prevents the spigot from pulling out of the bell is welded to the flare of the bell. A malleable ring transmits the load between the spigot and wedge ring to insure uniform distribution when the joint is not aligned perfectly.

Bolt-tied joints also retain some joint flexibility. With these joints, longitudinal loads are transmitted to the cylinder or to independent bars. The number and diameter of bolts must be sufficient to withstand all forces likely to occur. Cast-steel tie bars that fit into sockets cast in the pipe wall may be used instead of bolts to reduce the number of ties.

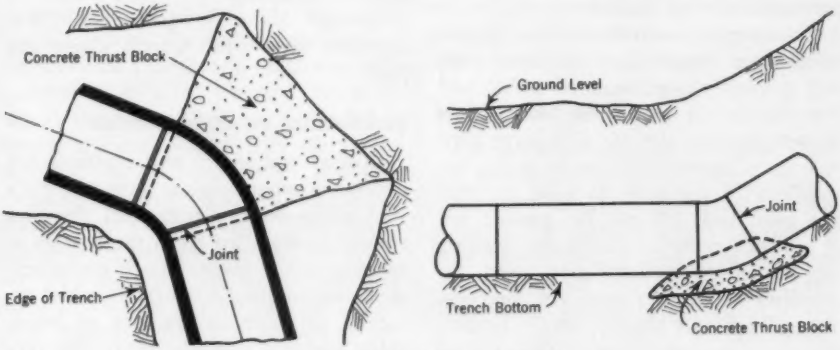

Fig. 19. Typical Thrust Blocks

Shown at the left, a top view of pipe in a trench, is a thrust block for a horizontal bend. The diagram at the right is a side view showing a vertical thrust block.

Clamp-tied joints maintain some joint flexibility and do not require special care to align lugs on adjacent pipe. Pipe to be harnessed is manufactured with lug rings welded to the bell and spigot rings. A channel-shaped split clamp is bolted around the joint in the trench so that it bears against the lug rings. A protective collar of mortar should be poured around the assembly.

Concrete encasement instead of thrust blocks, anchor blocks, or tied joints often may be used to advantage. The encasement is extended in

both directions from the elbow to provide enough weight to prevent movement. Frequently, the encasement is reinforced.

Highway and Railroad Crossings

Permits for crossing highways must be obtained from the authority having jurisdiction. Generally, the authority specifies how the crossing will be made. Methods employing open cuts, jacking, and tunneling are used, depending on local conditions. Usually, a pipe casing is not required. When pipe is properly designed, a concrete encasement may be required only when the cover is very shallow.

Crossings of mainline railroad tracks necessitate installation methods that will prevent curtailment of traffic and disturbance of the road bed. Most owners require the use of a large pipe casing to enclose the water main, regardless of the type of pipe, so that the road bed will not be washed out if a break occurs. Generally, jacking or tunneling methods are used for mainline crossings; open cut methods, for sidings and branch lines. Inspection by a representative of the railroad usually is required during the construction operations.

Unstable Foundations

Although concrete pipe filled with water does not impose a heavier load on the trench bottom than does the earth it displaces, it is necessary to provide a special foundation when soft and unstable material is encountered in the bottom of the trench. When unstable material extends for some distance below the trench bottom, piles are used to support the pipe. Under most conditions, if the trench is excavated below grade, dewatered, and filled to grade with gravel or crushed stone, a satisfactory pipe installation will be obtained.

Abnormal Trench Loadings

Abnormal trench loadings create special design and construction problems. These are solved by use of pipe of special design, improvement of bedding and backfilling, encasement of pipe in concrete, or construction of reinforced slabs or other structural supports across the trench above the pipe.

Installation on Steep Slopes

Special equipment and methods are necessary when pipe is installed on a very steep slope. In general, the pipe should be installed from the bottom to the top of the slope. Such equipment as dollies mounted on rails, cables attached to hoists or tractors, or heavy cable often is used to move the pipe into place.

Thrust blocks at the bottom and top of the slope must be carefully placed, and concrete collars extending into solid ground at intervals along the pipe are used to support the pipe and the backfill around it. Backfilling on steep slopes requires special attention. Erosion over the trench can be avoided by the use of slope paving or the planting of vegetation that resists erosion.

9. Field Testing and Disinfecting

Before the pipeline is accepted by the owner, it usually must pass a field hydrostatic test. The contractor who lays the pipe may test the pipeline in sections or as a completed unit. The test is made with the use of valves, when available, or by placing temporary bulkheads in the pipe and filling the line slowly with water. Care must be taken to insure that all air vents

are open during the filling to allow the escape of entrapped air.

After the line has been completely filled, it should remain under a slight pressure for a sufficient length of time to permit the concrete to absorb water and to allow the escape of air from slight air pockets. During this period, the bulkheads, valves, and connections should be examined for leaks. If any are found, they should be stopped by suitable methods.

Hydrostatic Test

For the hydrostatic test, a pressure at least equal to the design working pressure is maintained for a number of hours, and the water necessary to provide this pressure is measured with a meter or by other means. The leakage is the amount of water, needed to maintain the pressure, that enters the pipeline during the test, less the measured leakage through bulkheads, valves, and connections. The allowable leakage usually specified for cylinder pipe is 25–75 gal/in. of diameter per mile of pipe per 24 hr; the allowable leakage for noncylinder low-pressure pipe is 100–150 gal/24 hr.

Test of Subaqueous Lines

Subaqueous lines that carry water under pressure are tested generally by the application of pressure between valves or bulkheads in the same manner as with pipelines on land. In some instances, pipe for subaqueous lines is made heavy enough to keep it from floating when dewatered. Such pipe is tested by the application of air under pressure. The location of a leak in the pipe is disclosed by air bubbles on the surface of the water.

The working pressure of water intake lines is negligible, and leakage tests for these lines are often made by "infiltration" methods. A suction pump is connected to a high point of each test section. The pipe cannot float if water is kept in the line. Infiltration is measured by the amount of water removed from the line when water is pumped through it for a prescribed period of time. If the pipe is heavy enough to prevent flotation, the subaqueous installation often is tested by dewatering and visible inspection.

Disinfection of Mains

Although precautions are taken during installation to prevent dirt, trench water, and other foreign material from entering the pipe, it usually is necessary to disinfect a new concrete line before it is put into service. Of particular importance is the disinfection of pipelines that carry filtered water or water that will not be treated after it leaves the new line.

AWWA Standard C601 is an excellent guide to practical and workable procedures for disinfecting water mains.[7] This document covers preliminary flushing, materials, and methods used in disinfecting pipelines and contains recommendations for final flushing, sampling, and testing.

10. Tapping Pipe After Installation

Whenever possible, outlets for future connections to a pipeline should be incorporated in the pipe during manufacture. The cost of doing this is 40–70 per cent less than the cost of pressure tapping the pipeline when the connection is made, depending on the outlet size and pipe diameter. If outlets were not incorporated at the time of manufacture because the need for future connections had not been anticipated, new connections on existing

pipelines can be made readily with or without interruption of service.

Service Connections

Service connections can be made while the pipeline is under full operating pressure. Fittings are available for making threaded connections 0.5–2 in. in diameter in various types of concrete pressure pipe. For steel cylinder pipe, a gland threaded to receive a corporation cock confines an O ring rubber gasket against the cylinder after the outer concrete and steel reinforcements have been removed. In most instances, the gland is held in place by a small saddle and U bolts placed around the pipe. A corporation cock is screwed into the gland, a standard drilling machine is attached to it, and the tap is completed (Fig. 20).

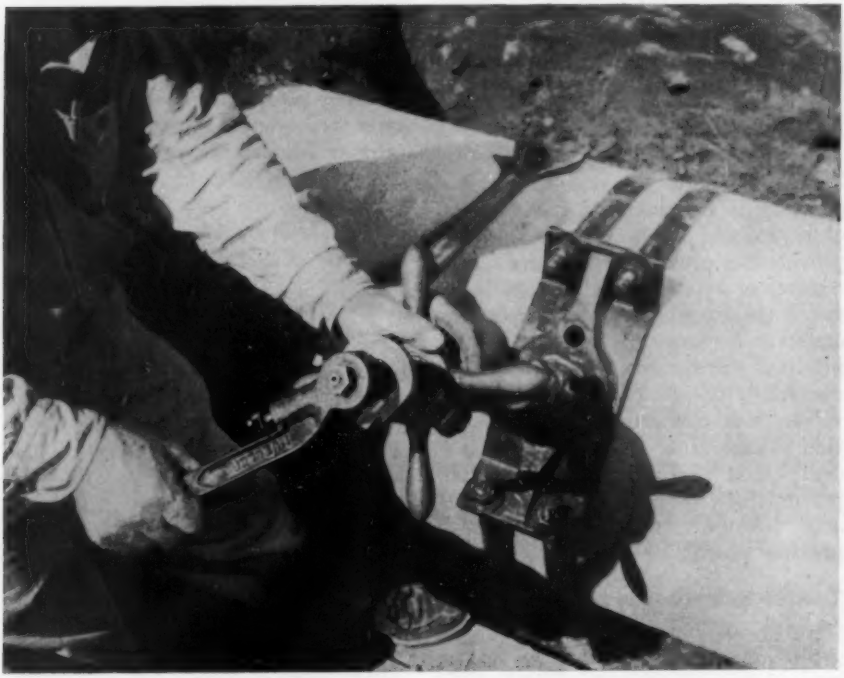

Fig. 20. Threaded-Outlet Tapping Assembly

A threaded-outlet tapping assembly with standard drilling machine attached is used to make service connections in various types of concrete pressure pipe. Shown is the saddle, corporation cock, and drilling machine in place for making the connection.

Flanged Outlet Taps

Flanged outlet taps can be made under pressure for branch lines with diameters as large as one size smaller than that of the pipe to be tapped. The assemblies used for the various types

of steel cylinder pipe are the same except for their dimensions. They consist of a saddle, U bolts, and a flanged gland that seals against the cylinder. A standard tapping valve is attached to the gland, and the tapping machine is attached to the valve (Fig. 21). The core is then cut and removed from the pipe. For concrete pressure pipe without a steel cylinder, the flanged outlet neck is welded to the saddle. The seal is made watertight by a rubber gasket compressed between the concrete and the saddle adjacent to the flanged neck. The tapping procedure is essentially the same as the procedure for concrete pressure pipe with steel cylinder, mentioned before.

Taps for large diameters can also be made without the use of a tapping machine when it is practical to dewater the pipeline. The concrete is removed with hand chisels or pneumatic tools; the steel cylinder is removed with chisels and a cutting torch. The outlet neck is welded to the cylinder for watertightness and to the saddle for additional strength. When a branch of the same diameter as that of an existing line is required, a straight length of pipe must be removed and replaced with a tee and a closure.

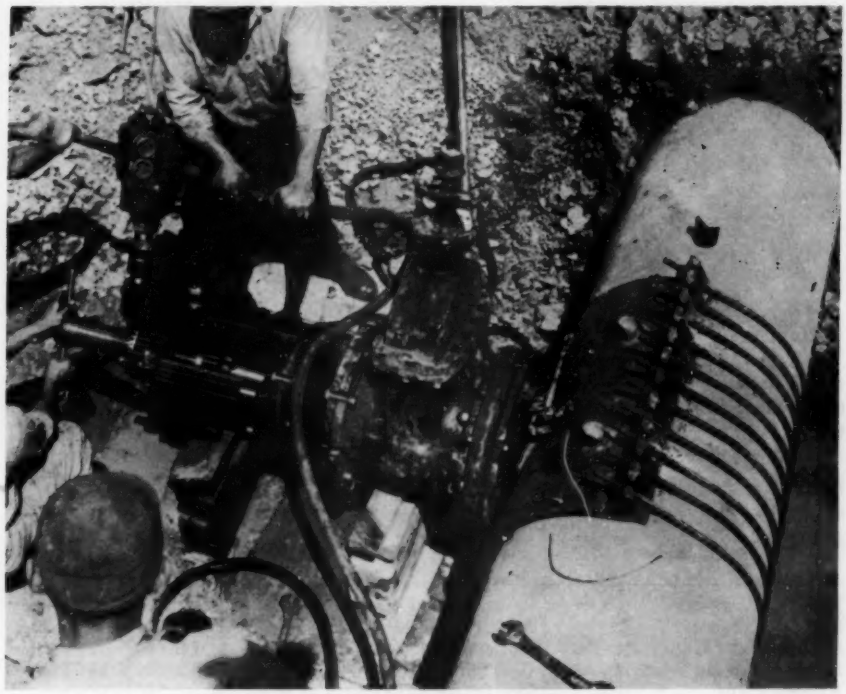

Fig. 21. Flanged Tapping Assembly

In the photograph, the saddle, tapping valve, and air-motor–operated tapping machine are being used to make a branch connection in concrete cylinder pipe.

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CHAPTER 4 AWWA M8

Distribution Storage

AWWA Distribution Manual

A training course in water distribution has been prepared under the supervision of AWWA Committee 4620 M—Education. The document is being published in installments (April 1961 issue, p. 458; June 1961 issue, p. 790), and will afterwards be made available as a separate volume.

THE necessity for storage of water in order to have a supply available when needed was probably the genesis of the earliest public water systems. Storage is an essential element of any water system, and it is becoming more and more important as continuing growth, expanding service areas, and additional uses increase the demand for water.

The term "distribution storage," as it is used here, should be understood to include the storage of water at the point of processing ready for distribution, but not the impoundment of water for supply purposes and long-term drafts, whether processed or not. The latter is properly an element of the supply works rather than the distribution system.

Functions of Distribution Storage

The principal function of distribution storage is to make it possible to process the water at times when facilities would otherwise be idle and to distribute and store it in advance of its actual need at one or more locations in the service area closer to its ultimate user. The principal advantages of distribution storage are:

1. The demands on the sources of supply, the production works, transmission and distribution mains are more nearly equalized, and the sizes or capacities of these elements of plant need not be so great.

2. System flows and pressures are improved and stabilized better to serve the customers throughout the service area.

3. Reserve supplies are provided in the distribution system for contingencies such as fire fighting and power outages.

That portion of distribution storage related to normal operating uses serves to provide a supply at various points in the distribution system to help meet the peak rates and more nearly equalize the rates of flow and pressures. In effect, it decreases the necessary size of, and investment in, the facilities through which the water passes before reaching the point of storage.

TABLE 4.1

*Water Use and Storage Depletion on the Maximum Day in a Typical City**

Hour	Ratio of Hourly Demand Rate to Max.-Day Demand Rate	Hourly Variation in Distribution Storage Reserve *mil gal*	Cumulative Storage Depletion *mil gal*
7–8 AM	1.00	−0.00	0.00
8–9	1.10	−0.10	0.10
9–10	1.25	−0.25	0.35
10–11	1.28	−0.28	0.63
11–12	1.20	−0.20	0.83
12–1 PM	1.18	−0.18	1.01
1–2	1.16	−0.16	1.17
2–3	1.10	−0.10	1.27
3–4	1.00	−0.00	1.27
4–5	1.08	−0.08	1.35
5–6	1.15	−0.15	1.50
6–7	1.30	−0.30	1.80
7–8	1.60	−0.60	2.40
8–9	1.40	−0.40	2.80
9–10	1.25	−0.25	3.05†
10–11	0.90	+0.10	2.95
11–12	0.85	+0.15	2.80
12–1 AM	0.70	+0.30	2.50
1–2	0.60	+0.40	2.10
2–3	0.50	+0.50	1.60
3–4	0.50	+0.50	1.10
4–5	0.50	+0.50	0.60
5–6	0.60	+0.40	0.40
6–7	0.80	+0.20	0.20
7–8			0.00

* Average day, 16 mil gal; maximum day, 24 mil gal; constant hourly pumping rate (at maximum-day demand rate), 24 mgd, or 1 mil gal per hour.
† Maximum storage depletion.

That portion of distribution storage related to contingency reserves, such as for fire protection or protection against failures in plant facilities, is recognized by the NBFU as follows*:

Where storage is provided, its ability to maintain supply with one pump and two pumps out of service shall be considered. To have no deficiency, pumps and storage shall be able to provide required fire flow for the specified duration during a period of 5 days with consumption at the maximum daily rate.

Thus, it is obvious that distribution storage serves two opposing roles; on the one hand, the stored water must be used to meet the variations in demand, whereas on the other it is desirable to keep the amount of storage intact for contingencies. These two opposing functions must be considered

* *Standard Schedule for Grading Cities and Towns of the United States With Reference to Their Fire Defenses and Physical Conditions.* National Board of Fire Underwriters, New York (1956).

separately and combined in computing the amount of storage that should be provided.

Location, Capacity, and Elevation

The location, capacity, and elevation of distribution storage are closely associated with the water demands and their variation throughout the day in different parts of the system. Rarely can distribution storage be economically justified in much greater amount than will take care of the hourly variation during the day and provide the requisite reserve for fire protection and minor contingencies. Storage in the distribution system should normally be replenished each night or during low-demand periods. Table 4.1 sets forth typical daily and hourly variations; such data are of great

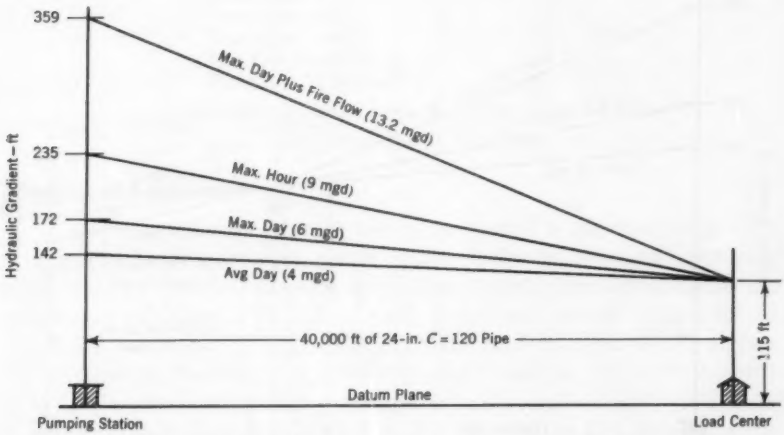

Fig. 4.1. Hydraulic Gradients With No Storage

assistance in working out the required storage capacities. Of course, each system has its own requirements.

Normally, it is more advantageous to provide several smaller storage units in different parts of the system than to provide an equivalent capacity at a central location. Smaller pipelines are required to service decentralized storage, and other things being equal, a lower flow line elevation and pumping head result.

In normal operating service, some storage should be used each day not only to maintain continuity in the output of the production and pumping works, but also to insure circulation in the stored water.

The quantity of water in storage and its elevation and location should properly be related to the maximum demands in different parts of the system. These are local variables and can be determined only after a careful

analysis and study in each system. There are some general rules that may serve as a guide to such individual analyses, however.

The provision of effective and usable storage amounting to 15–20 per cent of the average pumpage permits a fairly uniform production rate. In systems of moderate size, the amount of storage available and usable for equalizing production is 30–40 per cent of the total storage available for regulation and contingency reserves.

For example, in a system serving 150,000 people in a residential city with moderate commercial and industrial development, the average daily use should approximate 16 mil gal. Table 4.1 illustrates the hourly rate of use and storage depletion on the maximum day of 24 mil gal (150 per cent of the average day) with a uniform hourly production rate of 24 mgd.

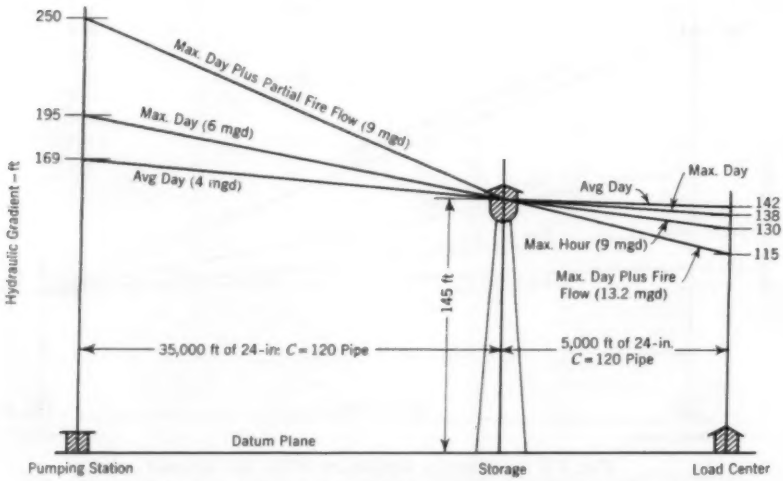

Fig. 4.2. Hydraulic Gradients With Storage Between Pump Station and Load Center

According to the NBFU, the fire reserve requirements in a city of this size should be 11,000 gpm over a 10-hr period, or a total of 6.6 mil gal. The total storage depleted in equalizing the production rate on the maximum day is thus 3.05 mil gal. That amount, combined with the fire reserve, brings the total storage required to 9.65 mil gal. Of the total 9.65 mil gal of storage, the fire reserve (6.6 mil gal) is 68.5 per cent and the regulation storage is 31.5 per cent.

Hydraulics of Distribution Storage

The principles of distribution storage design and the effects of placement of storage in the system can best be illustrated by comparisons of operating

results without storage with the results with storage between the supply point and the major load center or beyond the major load center.

For purposes of illustration, the model system considered below (Fig. 4.1–4.3) will be assumed to be one serving a population of 27,000 and having the demand characteristics listed in Table 4.2. It will further be assumed that the minimum pressure to be maintained at the load center is 50 psi (115 ft of head) and that system pipelines are in all cases expressed as equivalent lengths of 24-in. $C = 120$ pipe.

TABLE 4.2

Demand Characteristics of Model System

Item	Demand Rate *mgd*
Average day	4
Maximum day	6
Maximum hour	9
Fire flow required	7.2*
Maximum 10-hour rate	13.2†

* The fire reserve necessary to supply water at the rate of 7.2 mgd for 10 hours would be 3 mil gal.
† Maximum-day demand plus 10-hour fire flow requirement.

Effect of No Storage

If, in the system under consideration, no storage is provided (Fig. 4.1), at a given demand rate the pump station hydraulic gradient (pumping head) must be sufficient to overcome system losses at that demand rate and maintain a minimum of 115 ft of head at the load center. Thus, at the average-day demand (4 mgd), the pumping head required is 115 ft plus the head loss in 40,000 ft of equivalent pipe at 4 mgd, or $115 + (0.67 \times 40) = 142$ ft; at the maximum-day demand it is $115 + (1.42 \times 40) = 172$ ft; at the maximum-hour demand it is $115 + (3 \times 40) = 235$ ft; and at the maximum-day demand plus the fire flow (a total of 13.2 mgd) it is $115 + (6.1 \times 40) = 359$ ft.

Storage Ahead of Load Center

If, as shown in Fig. 4.2, 175 mil gal of storage is located 145 ft above the datum plane and at a distance of 35,000 ft from the pump station (5,000 ft ahead of the load center), the pumping head at a given pumping rate must be sufficient to pump against the head at the storage tank and overcome system losses at that pumping rate.

Average day. At the average-day demand, the required pumping rate (no water taken from storage) is 4 mgd. The pumping head required is equal to the hydraulic gradient at the tank *plus* the head loss in 35,000 ft of equivalent pipe at 4 mgd, or $145 + (0.67 \times 35) = 169$ ft. The hydraulic gradient at the load center is that at the tank (145 ft) *minus* the head loss in 5,000 ft of equivalent pipe, or $145 - (0.67 \times 5) = 142$ ft.

Maximum day. At the maximum-day demand, the required pumping rate is 6 mgd (no water taken from storage). The pumping head required is equal to the hydraulic gradient at the tank plus the head loss in 35,000 ft of equivalent pipe at 6 mgd, or $145 + (1.42 \times 35) = 195$ ft. The hydraulic gradient at the load center is that at the tank minus the head loss in 5,000 ft of equivalent pipe at 6 mgd, or $145 - (1.42 \times 5) = 138$ ft.

Maximum hour. At the maximum-hour demand, the flow in the 5,000 ft of pipe between the tank and the load center must be 9 mgd. The hydraulic gradient at the load center is that at the tank minus the losses in 5,000 ft of equivalent pipe at 9 mgd, or $145 - (3 \times 5) = 130$ ft. The pumping head required is equal to the hydraulic gradient at the tank plus

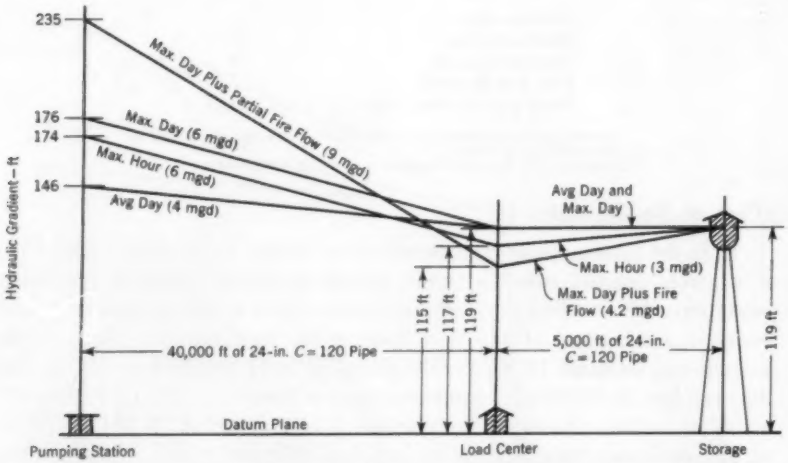

Fig. 4.3. Hydraulic Gradients With Storage Beyond Load Center

the head loss in 35,000 ft of equivalent pipe at the chosen pumping rate. If 3 mgd is to be supplied from the tank storage and the remaining 6 mgd is to be supplied from pumping, the pumping head required is $145 + (1.42 \times 35) = 195$ ft.

Maximum day plus fire flow. At the maximum-day demand plus the fire demand, the flow in the 5,000 ft of pipe between the tank and the load center must be 13.2 mgd. The hydraulic gradient at the load center is that at the tank minus the head loss in 5,000 ft of equivalent pipe at 13.2 mgd, or $145 - (6.1 \times 5) = 115$ ft. If it is decided to supply 4.2 mgd from storage and pump the remaining 9 mgd, the pumping head required is equal to the hydraulic gradient at the tank plus the head loss in 35,000 ft of equivalent pipe at 9 mgd, or $145 + (3 \times 35) = 250$ ft.

Storage Beyond Load Center

In the arrangement shown in Fig. 4.3, 1.75 mil gal of storage is provided 5,000 ft beyond the load center (45,000 ft from the pump station) at an elevation of 119 ft above the datum plane. When no water is being taken from storage, at a given demand rate the pumping head must be sufficient to pump against the head at the tank and overcome losses between the pump station and the load center at that demand rate. When part of the demand is being supplied from storage, however, the pumping head need only be sufficient to pump against the head at the load center and overcome losses in the pipeline between the pump station and the load center.

Average day. At the average-day demand, the required pumping rate is 4 mgd (no water taken from storage). The pumping head required is equal to the hydraulic gradient at the tank plus the head loss in 40,000 ft of equivalent pipe, or $119 + (0.67 \times 40) = 146$ ft. The hydraulic gradient at the load center is thus identical to that at the tank (119 ft).

Maximum day. At the maximum-day demand, the required pumping rate is 6 mgd (no water taken from storage). The pumping head required is equal to the hydraulic gradient at the tank plus the head loss in 40,000 ft of equivalent pipe at 6 mgd, or $119 + (1.42 \times 40) - 176$ ft. The hydraulic gradient at the load center is identical to that at the tank (119 ft).

Maximum hour. If, at the maximum-hour demand (9 mgd), it is decided to supply 3 mgd from storage and the remaining 6 mgd from pumping, the hydraulic gradient at the load center is that at the tank minus the head loss in the 5,000 ft of pipe between the tank and load center at the storage discharge rate of 3 mgd, or $119 - (0.4 \times 5) = 117$ ft. The pumping head required is equal to the hydraulic gradient at the load center plus the head loss in 40,000 ft of equivalent pipe at 6 mgd, or $117 + (1.42 \times 40) = 174$ ft.

Maximum day plus fire flow. In order to maintain a head of 115 ft at the load center, the flow in the 5,000 ft of pipe between the load center and the tank cannot exceed that at which the head loss is 4 ft, which is 4.2 mgd. Thus the remainder of the demand (9 mgd) must be supplied from pumping. The pumping head required is equal to the hydraulic gradient at the load center (115 ft) plus the head loss in 40,000 ft of equivalent pipe, or $115 + (3 \times 40) = 235$ ft.

In the analyses above, the designer has provided 1.75 mil gal of storage for fire demands. Thus the highest rate of flow that can be sustained for the required 10 hr is 4.2 mgd. The remainder of the fire flow (3 mgd) and the maximum-day demand (6 mgd) must be supplied from pumping. The fact that the pumping rate (9 mgd) is the same as the maximum-hour demand is only a coincidence.

Conclusions

Several conclusions can be drawn from the above analyses:

1. If no storage is provided, 124 ft (359 ft minus 235 ft) more pumping head is required to furnish the maximum-day demand plus fire flow than if adequate storage is provided beyond the load center. With the increased pumping rates required with no storage, the power needed is approximately 1,100 hp, as against 495 hp with storage, or more than twice as much.

2. Similarly, furnishing the maximum-hour demand without storage would require 500 hp as against 245 hp, still more than twice as much.

3. The capacities of the pumps required under these two conditions would be 13.2 mgd at 359-ft head as against 9 mgd at 235-ft head and 9 mgd at 235-ft head as against 6 mgd at 174-ft head.

4. During average- and maximum-day demands, the pumping head at the source is approximately the same.

5. In comparing storage located between the source and the load center with storage located beyond the load center, the examples illustrate that an increase in height is necessary if the storage is between the source and the load center. To secure approximately equivalent pressure results, the flow line of storage in the first instance must be 26 ft (145 ft − 119 ft) higher than if the storage feeds back to the load center from a point beyond.

6. Pumping heads are substantially lower under all rates of flow, and pressure is more uniformly regulated, if the storage is located beyond the load center.

7. The area served is substantially greater and the pressures are better regulated by storage located beyond the load center than by storage located between the pumping station and the load center.

The design chosen is based on replenishing, within the 24 hr during which a major fire occurs, all water taken from storage for fire fighting. This is more than is required by NBFU, which specifies that the capacity remaining after a major fire superimposed on 5 days of the maximum-day demand must be sufficient to supply the maximum day.

The maximum required pumping head would be reduced from 235 ft to 182 ft if all water used for fire fighting (7.2 mgd) were provided by storage, and the pumps would only have to operate at 6 mgd. If the system were so designed, however, the tank would have to be raised 6 ft in order to maintain 115 ft of head at the load center, and the fire storage would have to be increased to 3 mil gal. Fire storage would then amount to 50 per cent of the maximum day and 75 per cent of the average day, and that much storage might not be economically justified. On the other hand, if the storage is not provided, an additional 3 mgd of pumping capacity is required, and the production and supply works must also be capable of increased output, unless finished-water storage is provided ahead of

the pump station. Generally, therefore, an economic and engineering study should be made to determine the most efficient way to provide the required capacity.

Distribution Storage Facilities

The principal types of distribution storage facilities in common use are:

1. Lined or unlined earth embankment reservoirs, generally uncovered
2. Ground and underground storage reservoirs, covered or uncovered, constructed of standard or prestressed reinforced concrete
3. Steel ground storage reservoirs, gravity and repumped types
4. Elevated steel or concrete tanks and standpipes
5. Steel pressure storage tanks.

Earth Embankment Reservoirs

Earth embankment reservoirs were probably the first type of distribution storage in common use. They were generally installed on higher ground in, or closely adjacent to, the service area and were served by gravity, "floating" on the hydraulic elevation of the system, filling and discharging as required by the system demands. The early earth embankment reservoirs were generally constructed in a favorable location by partial excavation and partial embankment; paved with stone riprap, brick, or concrete on the slopes and bottoms, and almost always open.

These installations were, and still are, in most instances, effective and valuable in system operation, and, where the topography and soil conditions were favorable near the service area, earth embankment reservoirs could be constructed economically—particularly in the larger sizes. Nevertheless, they are nowadays seldom built, and those still in service are rapidly being retired. There are a number of reasons for this trend. In the first place, water stored in open reservoirs is susceptible to pollution and deterioration. Moreover, there is usually a certain loss of water by leakage through the embankment and bottom and evaporation from the surface. The expansion of service areas and the demand for higher distribution pressures have generally had the result that these reservoirs are below present system pressure. Also, the common use of sodium hexametaphosphate for specific treatment problems is incompatible with exposure of water in open reservoirs, because it contributes to increased algal growths.

Most state health departments recommend that distribution storage reservoirs be covered, and many now prohibit open reservoirs. The cost of covering earth embankment reservoirs is exceedingly high, and it is generally less expensive to replace the capacity, in part at least, with other storage facilities.

Concrete Reservoirs

After wrought-iron and steel standpipes and tanks, the next types of storage to be developed in common practice were the concrete ground and underground basins. At first, most concrete reservoirs were uncovered, but they were generally roofed with wood or concrete later. Such facilities, when open, have the same limitations as open earth embankment reservoirs, but when they are covered the sanitation problem is pratically eliminated.

The depth of concrete reservoirs is generally limited to 20–25 ft because of the difficulty of design and need to maintain watertightness. They are susceptible to earthquake damage, and, when located in colder climates and left open and exposed to freezing action, their maintenance eventually becomes both difficult and costly.

Of more recent development, circular, prestressed-concrete reservoirs have been installed in many locations, both above and below ground, with considerable savings in cost over the plain reinforced-concrete basin. Prestressed concrete has the additional advantages of increased watertightness and lower maintenance costs.

Steel Reservoirs, Tanks, and Standpipes

Steel reservoirs, tanks, and standpipes have rapidly forged ahead in providing a wide variety of storage holders for use at various points in a distribution system. The more common facilities of this type include ground storage reservoirs, standpipes, elevated tanks, and closed steel pressure tanks for remote or unduly elevated sections of the service area.*

Before welding became common practice, steel holders were constructed with riveted joints. The more modern, welded steel reservoir or tank is permanently watertight, and permits little or no evaporation from the water surface. Steel tanks can be made in countless shapes and sizes to serve various purposes in water service. The material used has strength and well defined safety limits. Unfortunately, however, steel of the grades commonly used in water storage facilities is subject to corrosion. For this reason periodic painting and sometimes repairs are a necessity, although such maintenance is easy to perform and relatively inexpensive.

Painting. Intervals between paintings of steel structures vary considerably depending upon a number of factors. An interval of approximately 5 years between thorough paint jobs might be a fair average. Successful and economical maintenance of steel structures by painting depends upon: (1) proper surface preparation, (2) selection of suitable paints, (3) good workmanship in application, (4) adequate drying and aging, and (5) proper

* The difference between a reservoir and a standpipe has been quite generally defined to be that when the diameter of the tank exceeds the height, it is termed a reservoir, and when the height is greater, it is termed a standpipe.

maintenance through periodic inspection and spot, partial, or complete removal of old paint and repainting when necessary.

Cathodic protection. Properly applied and maintained cathodic protection is playing more and more part in the protection of steel or iron surfaces. Cathodic protection reverses the flow of current which tends to draw iron from the surface and thereby produce rust and corrosion. It operates by inducing a reverse current from electrodes placed in the water through the water as an electrolyte to the metal surface. Improvements in the design and installation of cathodic-protection equipment are constantly being made. Because of the difficulty of painting the interior surfaces of water holders and the difficulty of securing adequate paint jobs, it is well to investigate cathodic protection as an extra measure against corrosion.

Storage and Booster Pumping

In some service areas where topography does not permit the economical location of storage at the desirable hydraulic elevation of the system, ground storage and booster pumping may be the most logical means of providing adequate storage. The economy and desirability of pumped storage as compared to elevated storage must be determined in each individual area. In many areas, ground storage with booster pumping, even after capital and operating costs of the booster station, may be found to be more economical. This must, however, be weighed against the dependability of readily available elevated storage. If substantial storage capacity is necessary, a combination of ground and elevated storage may be the best solution.

Many systems have older storage facilities, which, because of increased pressures or enlargement of service areas, are located below the hydraulic elevation of the system. These facilities can be restored to usefulness by the provision of automatic or manual booster stations to pump this storage to the system. Often only the top few feet of storage may be useful. By proper installation of pumps and controls, it becomes possible to use almost all of the low-pressure storage.

Most systems have areas in which a relatively few customers are located on very high or remote points. These points can generally be served adequately by providing a small booster system and pneumatic steel pressure tank operating automatically on pressure control. Such systems, properly designed, are completely effective in providing the normal domestic requirements. If fire protection is required, it can be furnished by locating one hydrant on each side of a valve segregating the area and making arrangements with the local fire department to use its pumpers, pumping from one hydrant to the other. The pressures obtained are generally adequate to supply direct fire streams at the location of a fire.

Notes and Comment

Survey of Aqueduct Maintenance Practices

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In connection with preliminary design studies for a major aqueduct, a 1959 survey of a number of water supply agencies was made to compile information concerning the scope and nature of maintenance practices relating to existing aqueducts. Information, in the form of completed questionnaires, was received from fourteen water departments. The departments surveyed were selected so that they provided a representative cross section of water operations throughout the country (one contributor was from Canada).

Considerable interest in the results of the survey was evidenced by the complete cooperation and enthusiastic participation of the departments. In many instances, detailed comments and comprehensive remarks were submitted in addition to the completed questionnaire. It became apparent that aqueduct maintenance practice is a phase of water supply operation that varies widely. Accordingly, it was felt that the information compiled might be of interest to many in the water supply field.

Results of the survey are shown in Table 1, which lists the items included in the questionnaire and, in addition, aqueduct materials and Hazen-Williams C value. The two additional items either were voluntarily included by the contributing departments or submitted later as a result of direct inquiry.

Notes to Table 1

Some entries in Table 1 require qualification. The comments below, from correspondence received from the participating water departments, serve to clarify conditions and circumstances not evident from the table. In addition, some of the comments are of an advisory nature, suggesting procedures that have proved effective. Comments *a* to *l* refer to letters in parentheses shown in the table.

a. Hartford, Conn. The size range is 36 in. to 64×72-in. horseshoe.

b. Hartford, Conn. The Hazen-Williams coefficient for the pipelines has been reduced to 100–110 because of deposits of iron, manganese, and organic matter on pipe walls. Experimental work with chemicals is now being conducted in an attempt to remove deposits and improve coefficients.

c. Metropolitan Water District of Southern California. The length shown is for the main aqueduct only, which contains no pipe smaller than 162 in. in diameter.

d. New York, N.Y. A separate Long Island system is being maintained on a standby basis for the Rockaways in Queens until the reinforcement of the transmission system is completed.

e. New York, N.Y. The size range is 89×101.5-in. horseshoe to 234 in.

f. New York, N.Y. Because of budgetary limitations, there is no regular patrol of the aqueducts. At present, the aqueducts are inspected only by maintenance forces, engineers, and others in the course of their regular work. For example, when a gang is working at any point, the foreman will inspect the aqueduct for 2–3 mi on either side of the

TABLE 1

*Survey of Aqueduct Maintenance Practices**

Location	Description of Aqueducts						Frequency of Inspection†		Items Included in Periodic Inspection				Maintenance Work				
	No.	Size *in.*	Length *mi*	Year Placed in Service	Materials Used	Hazen-Williams *C* Value Recorded	Cross-Country	Along Traveled Way	Leaks	Air Valves	Encroachment on Right of Way	Line Valve Operation	Internal Cleaning	Servicing Line Valves	Structure, Fence, Gates, Repairs	Clearing Right of Way	Other
Colorado Springs, Colo.	3	20–30	2–88	1925, 1941, 1957	steel		Q M W		x	x			x				
Denver, Colo.	2	16–96	12–25	1919–59	reinforced concrete, cast iron, steel		Q	W	x	x	x	x	x	x	x		
Hartford, Conn.	3	36 (a)	7–11	1920, 1942, 1944	cast iron, reinforced concrete	yes	Q	W	x					x			(b)
Metropolitan Water Dist. of S. Calif.	1	162–192 (c)	242	1938–59	steel, cast iron, concrete, reinforced concrete	yes	D	D	x	x	x	x	x	x	x	x	
New York, N.Y.	4 (d)	234 (e)	31–111	1842–1954	brick, steel, cast iron, masonry, concrete tunnel		(f)	(f)	x		x				x	x	(g)
Norfolk, Va.	4	30–48	2–30	1921, 1940, 1943, 1951	cast iron, reinforced concrete, steel		M	M	x	x			x				
Oakland, Calif.	2 (h)	54–68	81	1929, 1949	steel, concrete	yes	D	D	x		x		x	x	x	x	(i)
Pittsfield, Mass.	3	12–30	2–5	1890–1909, 1920, 1950	prestressed concrete, cast iron		W	D	x				x				
Portland, Me.	3	30–48	5–14	1903, 1912, 1938	cast iron, reinforced concrete		A	A	x	x		x		x		x	
Providence, R.I.	1	48–90	14	1928	steel, reinforced concrete, masonry		W	D	x				x				
San Diego, Calif.	1	48–72	72	1947	concrete, steel			B	x	(j)	x				x		
San Francisco, Calif.	7	54–78	12–48	1903–53	concrete, steel	yes	M	W	x	x	x	x	x	x	x	x	
Tulsa, Okla.	2	54–108	53–54	1923, 1951	prestressed concrete	yes	D	D	x	x	x	x			x	x	
Winnipeg, Man.	1 (k)	48 (l)	96	1919	concrete	yes	D		x					x	x	x	

* For an explanation of letters (a) to (l), see "Notes to Table 1."
† Abbreviations used: A—annually; Q—quarterly; M—monthly; W—weekly; B—Biweekly; D—daily.

working area. The frequency of inspection, therefore, varies according to the work program and is correspondingly erratic with respect to any one point. Thus, some single points may occasionally be inspected at roughly 2-week intervals, but, in general, the frequency is not more often than once a month. As the Catskill and the Old Croton aqueducts are not paved for auto travel, there is no patrol in the spring of the year except by foot, because at this time, motor vehicles would tear up the soft sod and seriously damage the embankment cover.

The New Croton and Delaware aqueducts have only the shaft sites at the surface; hence, only these sites and the various control structures need to be inspected. This is done in conjunction with regular maintenance work plus an occasional checking or inspection trip.

g. New York, N.Y. All structures and pertinent equipment are kept in repair and metal work painted to the extent allowed by budgetary limitations on personnel and on expenditures for contracts and materials. In most places, the full width of the roadway is mowed and one width of a cutter blade is passed down each side of the embankment twice a year. In inhabited areas, brush growth has been reduced somewhat with cutting followed by chemical treatment.

Removal of rubbish deposited on the aqueduct strips is a major problem, most of all in populous areas, especially where heavy growths of brush make removal difficult. This is why every effort is made to cut down brush in these areas. Cleaning, snow removal, and repair of sidewalks, where the Catskill and the Old Croton aqueducts pass through densely builtup villages and towns, are labor-consuming chores. Snow must be cleared and sidewalks sanded for icy conditions, according to requirements of local ordinances.

For passing through populous areas, a subsurface pressure tunnel, such as the Delaware Aqueduct, is by far the best solution, if costs will allow it. The manifold maintenance problems of a surface aqueduct are thereby eliminated, and no problems will arise with respect to subsequent crossings by unanticipated highways, sewers, and water lines, many of which can be extremely troublesome.

A surface aqueduct should be so graded that it can be mowed *completely* with power equipment (this is not possible at the Catskill and the Old Croton aqueducts). Tree growth should be curtailed to prevent damage to the roofs of masonry conduits and interference with possible future repair work, and to avoid possible damage to adjacent properties by fire and the falling of dead trees and branches.

A surface aqueduct should, if possible, especially in populous areas, be completely enclosed by fencing to prevent vandalism, unauthorized trespassing, and depositing of trash and rubbish.

h. Oakland, Calif. An 87-in. aqueduct was being designed in 1959.

i. Oakland, Calif. The first Mokelumne Aqueduct consists of approximately 67 mi of buried steel pipe and 14 mi of exposed steel pipe, 10 mi of which are supported on timber piling and concrete bents in one section of the San Joaquin delta lands.

The second aqueduct is located 15–25 ft to the left, looking downstream, from the center line of the first aqueduct. A total of 71 mi of the aqueduct is buried; 10 mi across the delta are supported on concrete piles with steel bent supports; 66.4 mi of the aqueduct is steel pipe; 14.6 mi is precast steel cylinder concrete pipe.

The 14 mi of exposed pipe of the first aqueduct, asphalt-coated with aluminum finish coat, has been completely repainted once. Spot painting covering 2–3 per cent of the pipe is performed yearly. For the second aqueduct, exposed pipe primed with red lead or special primer * and finish coat aluminum, yearly painting of 5 per cent is required to maintain protection.

Approximately 600 valves and fittings are located in 500 structures along the aqueducts. Painting, flushing out vac-

* Made by Tnemec Co., North Kansas City, Mo.

uum relief valves, and replacing flange bolts as required are done yearly. Four automatic wasteways on each aqueduct require electrical and mechanical maintenance; 24 cathodic protection stations require replacement of anodes and electrical maintenance.

The right of way is 100 ft wide. From the Sierra foothills, near Campo Seco, Calaveras County, the aqueducts run through hilly pasture land for about 15 mi, then through grain, orchard, and row crop lands for 22 mi, to the Santa Fe Railroad near Holt, Calif. One major river is crossed below stream bed. Paralleling the south side of the Santa Fe right of way, the aqueducts cross the delta section for 10 mi aboveground over peat soil, which is below sea level. Two rivers are crossed below stream bed.

From the west side of the delta near Brentwood, Calif., the right of way runs 25 mi northwesterly, through orchard, pasture, and grain land, to the town of Port Chicago, Calif. Turning southwesterly, the right of way passes through farming and subdivision property for 9 mi to the Walnut Creek Tunnel, which is located about 2 mi northwest of the town of Walnut Creek, Calif.

Right-of-way maintenance consists of maintaining the aqueduct roadway, drainage, fences and gates, weed control, culverts, bridges, and property markers. Pasture and grain land require the least right-of-way maintenance. Orchards, subdivisions, and peat lands require the major expense, pertaining to fire hazard, weed control, and public relations.

A work crew of 21, including supervisory personnel, with a fiscal budget of $192,000 (as in 1958–59), is the usual crew and budget for a year of normal operation.

j. San Diego, Calif. Aqueducts have many open air vent structures. These are watched particularly during warm weather to check on buildup of bacterial growth, which reduces the Hazen-Williams coefficient, and to guard against overflowing.

k. Winnipeg, Man. A 66-in. diameter, 12-mi prestressed concrete pipe was under construction in 1959.

l. Winnipeg, Man. The size range is 48 in. to 129×108-in. horseshoe.

Fluoridation of Municipal Water Supplies

A summary of the conclusions and recommendations on fluoridation of municipal water supplies from a report made on Jan. 31, 1961, by the Fluoridation Committee of the Ministry of Health, Toronto, Ont.

A committee from the Ministry of Health, Toronto, Ont., appointed to inquire into, and report on, the fluoridation of municipal water supplies, unanimously reached these conclusions:

The committee:

1. Is convinced that the incidence of dental caries in Ontario is of such magnitude that it must be regarded both as a serious and as a major public health problem and that adequate treatment of dental caries in the whole population is beyond the resources of the dental profession

2. Is also convinced that the treatment of dental caries alone will not control or reduce the ultimate incidence of tooth decay

3. Realizes the importance of good oral hygiene but, at the same time, recognizes the limitations of a good oral hygiene program

4. Also realizes the importance of proper nutrition in the reduction of the incidence of dental caries but acknowledges, with some degree of astonishment, and with much concern, the inadequacy of overall nutrition in Ontario

5. Firmly believes that the reduction of the incidence of dental caries

is a problem of prevention, not one of treatment

6. Is convinced that it has been conclusively proved that the presence of fluoride, either naturally occurring or mechanically added, in a municipal or communal water supply, in concentrations of approximately 1 ppm, strikingly reduces the incidence of dental caries when such water is consumed during the period of tooth development, and that the caries-reducing effect of fluoride extends into adult life

7. Is also convinced that the long-term ingestion of fluoride in concentrations of approximately 1 ppm over a very wide range of water intake is not harmful to bodily health and that no fluorosis or aesthetic significance is specifically associated with it

8. Is satisfied that the equipment in use in municipal water systems for the addition of fluoride to the water supply is mechanically adequate for this purpose and that the concentration of fluoride is, and can be controlled, within the limits of optimal effectiveness and safety

9. Is also satisfied that the presence of fluoride in the recommended concentration does not cause corrosion of water mains, pipe, and fittings, nor does it affect adversely in any way industrial processes

10. Finds that the cost of fluoridating a municipal water supply is very reasonable in relation to the health benefit to the community

11. Believes that, at the present time, there is no practical alternative to the fluoridation of municipal water supplies in those areas where the water does not contain approximately 1 ppm fluoride

12. Holds the firm opinion that the fluoridation of municipal water supplies by the authority of appropriate legislation would not be a denial of any fundamental or basic civil right or liberty which the legislature of Ontario should protect and preserve.

The committee unanimously recommends that:

1. Legislation be enacted empowering municipalities to fluoridate their water supplies *

2. Such legislation should authorize municipalities to introduce fluoridation by bylaw, without the necessity of a referendum

3. Legislation be enacted authorizing the fluoridation of water supplies which are not controlled or operated by municipalities

4. The appropriate departments of the Ontario government should keep under constant review alternatives to fluoridation of municipal water supplies which may prove feasible for people living in areas not served by communal water systems

5. A sound, concerted program supplying accurate information on nutrition to the people of Ontario, as part of a total program of general health and dental health education, be implemented.

* Since the Fluoridation Committee made its report, the Ontario legislature passed Bill 98, entitled "An Act Respecting the Fluoridation of Public Water Supplies," also called the "Fluoridation Act, 1960–61."—EDITOR.

AWWA C700–61T

American Water Works Association

New England Water Works Association

TENTATIVE

AWWA STANDARD

for

COLD-WATER METERS—DISPLACEMENT TYPE

This "Standard for Cold-Water Meters—Displacement Type" is based upon the best known experience and is intended for use under normal conditions. It is not designed for unqualified use under all conditions, and the advisability of its use for any installation must be subjected to review by the engineer responsible for the installation in the particular locality concerned.

First Edition approved as "Standard" May 10, 1946; Second Edition approved as "Tentative" Jan. 23, 1961.

- **Price of reprint—25¢ per copy**
- **Approximate date available—Sep. 15, 1961**

AMERICAN WATER WORKS ASSOCIATION
Incorporated
2 Park Avenue, New York 16, N.Y.

Tentative AWWA Standard for

Cold-Water Meters—Displacement Type

Sec. 1—Scope

This standard covers the various types and classes of cold-water displacement meters for water works service and the materials and workmanship employed in their fabrication. The displacement meters covered, known as nutating- or oscillating-piston or -disc meters, are practically positive in action, and the pistons or discs displace or carry over a fixed quantity of water for each nutation or oscillation when operated under positive pressure.

Sec. 2—Information to Be Supplied by Purchaser

When placing orders for meters manufactured to conform to this standard, it will be necessary for the purchaser to supply specific supplementary information regarding the following:

2.1. Designation of AWWA C700 used.

2.2. Affidavit of compliance (Sec. 3) and certificate of testing for accuracy and capacity (see Note 3.1) if either will be required.

2.3. Size of meter (Sec. 4.2) and quantity required.

2.4. Whether $\frac{5}{8}$, $\frac{3}{4}$, or 1 in. meters are to be furnished with coupling nuts and tailpieces (Sec. 8.2 and 8.3).

2.5. Whether $1\frac{1}{2}$ and 2 in. meters are to be furnished with flanged ends or threaded ends (Sec. 9.1 and 9.2).

2.6. Whether flanged meters are to be furnished with companion flanges, gaskets, bolts, and nuts (Sec. 9.3 and 10.2).

2.7. Whether meters with nutating or oscillating type of piston or disc are to be furnished (Sec. 1).

2.8. Whether meters are to be furnished with a set of replaceable change gears (see Note 3.1).

2.9. Whether meters are to be of the split-case or frostproof type (Sec. 5.2).

2.10. Type of corrosion protection, if any, required for cast-iron bottom caps (See Sec. 6 and 18).

2.11. Type of register to be furnished—that is, round or straight reading, in US gallons or cubic feet (Sec. 11), and with or without test sweep hand (Sec. 11).

2.12. Whether the serial number of the meter shall be imprinted on the case (Sec. 5.4) as well as on the register box lid (Sec. 12).

2.13. Whether the main casing, register box rings, and covers for 3 in. meters and larger are to be made of copper alloys or of cast iron treated for corrosion resistance (Sec. 18.1 and 18.2).

2.14. If operating water temperatures are to exceed 80°F, permissible modifications of test specifications (Sec. 19 and Note 5.2).

2.15. If water is highly aggressive, whether special materials are required to resist corrosion (see Note 5.3).

Sec. 3—Affidavit of Compliance

The purchaser may require an affidavit from the manufacturer or vendor that the meters furnished under the purchaser's order comply with all applicable requirements of this standard.

Sec. 4—Capacity, Size, and Length

4.1. *Capacity.* Capacity or delivery and pressure loss limits for meters supplied under this standard shall be those shown in Table 1.

4.2. *Size.* The sizes of meters (Table 1) shall be in terms of the nominal size of opening in the inlet and outlet spuds or flanges.

4.3. *Length.* The lengths of meters (Table 2) shall be the overall length from face to face of the inlet and outlet meter spuds or flanges.

Sec. 5—Cases

5.1. All meters shall have an outer case with a separate measuring chamber in which the piston operates. Castings shall not be repaired in any manner. The inlet and outlet spuds or flanges shall be 180 deg apart and located in the same horizontal plane.

5.2. Casings shall be of either split-case or frost protection design, as designated by the purchaser.

5.3. The size, model, and direction of flow through the meter shall be cast, in raised characters, on the outer case of all meters.

5.4. The manufacturer's meter serial number, if required by the purchaser, shall be imprinted on the outer case.

5.5. Meters larger than 1 in. shall be so designed that all interior parts

TABLE 1

Capacity, Pressure Loss, Test Flow, and Piston Speed Limits for Positive Displacement Meters

Meter Size *in.*	Max. Capacity or Delivery Classification *gpm*	Max. Pressure Loss at Max. Capacity *psi*	Min. Test Flow *gpm*	Normal Test Flow Limits *gpm*	Max. No. of Piston Nutations or Oscillations	
					per 10 gal	per cu ft
⅝	20	15	¼	1– 20	580	435
¾	30	15	½	2– 30	333	250
1	50	15	¾	3– 50	153	115
1½	100	20	1½	5– 100	67	50
2	160	20	2	8– 160	40	30
3	300	20	4	16– 300	20	15
4	500	20	7	28– 500	9.3	7
6	1,000	20	12	48–1,000	4	3

may be removed without disturbing the connections to the pipeline.

Sec. 6—Frost Protection Devices

Frost protection devices, when provided, shall be of such design that they will yield or break under normal freezing conditions to minimize damage to any other part of the meter. The internal portion of bottom caps designed to afford frost protection may be protected against corrosion by an inner liner or coating.

Sec. 7—External Case Screws, Bolts, Nuts, and Washers

All external case screws, bolts, cap bolts, nuts, and washers shall be designed for easy removal after long service.

Sec. 8—Connections for ⅝-, ¾-, and 1-in. Meters

8.1. *Main-case connections.* Main-case connections of all ⅝-, ¾-, and 1-in. meters shall be meter casing spuds having external straight threads conforming to the American Standard pipe threads (ASA B2.1), as far as the specifications apply. Pitch diameters shall be those shown in Table 2. When a ⅝-in. meter is furnished with connections for ¾-in. pipe, the spud dimensions shall be as shown for the ⅝×¾-in. size.

TABLE 2

Dimensional Design Limits for Meters, External Connections, and Companion Flanges

Meter Lengths and Connections

Meter Size *in.*	Meter Length—*in.*		Meter Casing Spuds			Coupling Nuts		Couplings and Tailpieces	
	Screw Ends	Flange Ends	Nominal Thread Size *in.*	Min. Pitch	Max. Diameter *in.*	Min. Pitch	Max. Diameter *in.*	Length *in.*	Threads *in.*
⅝	7½		¾	0.978	0.988	0.992	1.002	2¾	½
⅝×¾	7½		1	1.227	1.237	1.242	1.252	2½	¾
¾	9		1	1.227	1.237	1.242	1.252	2½	¾
1	10¾		1¼	1.563	1.573	1.580	1.590	2⅝	1
1½	12⅝	13							
2	15¼	17							
3		24							
4		29							
6		36½							

Companion Flange Dimensions

Meter Size *in.*	Min. Thickness at Bolt Hole *in.*	Diameter of Bolt Circle *in.*	No. of Bolt Holes	Diameter of Bolt Holes *in.*	Thickness at Hub *in.*
1½	9/16	4	2	11/16*	13/16
2	⅝	4½	2	11/16*	⅞
3	¾	6	4	¾	1 3/16
4	15/16	7½	8	¾	1 5/16
6	1	9½	8	⅞	1 9/16

* Minimum.

8.2. *Coupling nuts.* Coupling nuts shall be tapped American Standard internal straight pipe threads (ASA B2.1), as far as the specifications apply. Pitch diameters shall be those shown in Table 2.

8.3. *Coupling tailpieces.* Coupling tailpieces shall be threaded to conform to American Standard external taper pipe threads (ASA B2.1) and have nominal internal diameter equal to the size of meter openings. Lengths and thread sizes shall be those shown in Table 2.

Sec. 9—Connections for 1½- and 2-in. Meters

Main-case connections for 1½-in. and 2-in. meters may be either spuds on both ends or flanges on both ends.

9.1. *Meter spuds.* Meter spuds shall be tapped 1½ in. and 2 in. respectively American Standard internal taper pipe threads (ASA B2.1).

9.2. *Flanged casings.* Meter casing flanged connections shall be faced and drilled and shall be of the oval type. The drilling shall be on the horizontal axis; the number of bolt holes; the diameter of the bolt holes and bolt circle shall be as shown for companion flanges in Table 2.

9.3. *Companion flanges.* Oval companion flanges, gaskets, bolts, and nuts shall be provided if specified by the purchaser. Companion flanges shall be faced, drilled, and tapped, 1½ in. and 2 in. respectively, American Standard internal taper pipe threads (ASA B2.1). Dimensions shall be those shown in Table 2.

Sec. 10—Connections for 3-, 4-, and 6-in. Meters

10.1. *Meter case connections.* All meter case connections for 3-, 4-, and 6-in. meters shall be flanged. The flanges shall be of the round type, faced and drilled, and shall conform to the American Standard cast-iron pipe flange, class 125 (ASA B16.1) as to diameter and drilling as shown for companion flanges in Table 2.

10.2. *Companion flanges.* Companion flanges, gaskets, bolts, and nuts shall be provided if specified by the purchaser. Companion flanges shall be faced, drilled, and tapped 3 in., 4 in., or 6 in. respectively, American Standard internal taper pipe threads (ASA B2.1) and conform to American Standard cast-iron pipe flange, Class 125 (ASA B16.1) as to diameter, drilling and thickness, all as shown in Table 2.

Sec. 11—Registers

Registers shall be round-reading or straight-reading, subject to the limitation set forth in Sec. 11.3, below, and shall read in US gallons or in cubic feet, as specified by the purchaser. They shall not be in fluid contact with the water being measured.

11.1. *Round-reading registers.* The register pinion and spur gears shall be firmly fastened on their spindles, shall mesh fully with each other and run freely, and shall be so constructed that they cannot become unmeshed. The spindle bearings in the top and bottom register plates shall be bushed. These bushings shall have sufficient depth to insure ample spindle bearing and sufficient clearance to allow the spindles to revolve freely, shall be so fitted that they will not work loose, and shall be removable.

11.1.1. If the register is sealed and thereby not subject to normal corrosion, gears and pinions may run free on fixed shafts or be fixed on shafts that run free in upper and lower plates,

or both, and shall be so constructed that they cannot become unmeshed.

11.1.2. The maximum indications of the initial dial and the minimum capacity of the register shall be those given in Table 3.

TABLE 3

Maximum Indication on Initial Dial and Minimum Register Capacity

Meter Size *in.*	Maximum Indication of Initial Dial		Minimum Capacity of Register	
	cu ft	*gal*	*mil cu ft*	*mil gal*
⅝	1	10	0.1	1
¾	1	10	1	10
1	10	100	1	10
1½	10	100	10	100
2	10	100	10	100
3	10	100	10	100
4	100	1,000	100	1,000
6	100	1,000	100	1,000

11.1.3. All the index circles, including the initial circle, shall be subdivided into ten equal parts. All hands or pointers shall taper to a point and shall be accurately set and securely held in place. Registers may have a center-sweep test hand with the index circle near the periphery of the register face graduated in 100 equal parts, each tenth numbered. The quantities indicated by a single revolution of the test hand shall be those given in Table 3.

11.2. *Straight-reading registers.* The numerals on the number wheels of straight-reading registers shall be large and distinct and easy to read. The register lock and side gears shall be securely fastened to their number wheel discs and hubs. The tumbler pinions shall mesh accurately at the turnover points with the lock and side gears of the adjacent number wheels. Both main and pinion shafts shall be so secured in the register frame that they cannot get out of position. The pinion shaft shall be so designed that there is no possibility of its bending and allowing the pinion to skip at the turnover point.

11.2.1. If the register is sealed and thereby not subject to normal corrosion, gears and pinions may run free on fixed shafts or be fixed on shafts that run free in upper and lower plates, or both, and shall be so constructed that they cannot become unmeshed. The tumbler pinion shall mesh accurately at turnover points with the lock and side gears of adjacent number wheels. Pinions may operate between number wheels mounted in partition plates.

11.2.2. The maximum indication of the digits appearing on the first number wheel and the minimum capacity of the register, shall be those given in Table 3.

11.2.3. The register face shall have a test index circle which shall be divided into ten equal parts. The hand or pointer shall taper to a sharp point and shall be accurately set and securely held in place.

11.2.4. Registers may have a center-sweep test hand with an index circle located near the periphery of the register face and graduated in 100 equal parts, each tenth numbered. The hand or pointer shall taper to a point and shall be accurately set and securely held in place. The quantities indicated by a single revolution of the test hand shall be those shown in Table 3.

11.3. *AWWA standard straight-reading register.* Any new model of meter, as distinguished from modification of existing models, supplied under this standard and first offered for sale

after the date of publication of this standard shall be equipped with AWWA standard straight-reading registers. The register face shall be of the center-sweep test hand type with an index circle located near the periphery of the register face and graduated in 100 equal parts, each tenth numbered. Register construction shall conform, in all other details, to Sec. 11.2 above.

Sec. 12—Register Boxes

The name of the manufacturer shall be cast in raised letters on the lid of all register boxes. The serial number of the meter shall be imprinted on the lid. The lid shall be recessed and shall overlap the register box to protect the glass. The glass shall be securely held in place. All register box compartments of meters having a stuffing box exposed to the atmosphere shall be provided with a drain hole $\frac{1}{8}$ in. in diameter.

Sec. 13—Intermediate Gear Trains

Intermediate gear trains may be mounted on the measuring chamber, in the upper main casing, or, when not exposed to water, combined with or adjacent to the register gearing. Gear trains exposed to water shall be of the oil-enclosed type, shall have a separate housing or form a housing with the main casing or measuring chamber, and shall operate in a suitable lubricant.

Sec. 14—Measuring Chambers

Measuring chambers shall not be cast as part of the outer casings. They shall be machined carefully and secured in position in the outer casings so that any distortion of the casings that might occur at an internal pressure of 150 psi will not affect the sensitivity or registration of the meters.

Sec. 15—Pistons or Discs

Pistons or discs shall be smoothly machined, shall be fitted accurately in their measuring chambers, and shall operate smoothly and freely. The plates of disc pistons, whether flat or conical, shall either be reinforced or equipped with thrust rollers. Disc pistons may be in one piece or composed of a piston plate and two half-balls. The piston spindles or shafts shall be securely fastened in the pistons. The piston or disc nutations or oscillations shall not exceed the quantities given in Table 1.

Sec. 16—Strainers

All meters shall either be provided with strainers or be self-straining by means of an annular space between the measuring chamber and the external case. Strainer screens shall be installed in the meter; they shall be rigid, fit snugly, be easy to remove, and have an effective straining area at least twice that of the main-case inlet.

Sec. 17—Seal Wire Holes

Register box screws, and inlet and outlet coupling nuts, if furnished, shall be drilled for seal wire holes. Seal wire holes shall be not less than $\frac{3}{32}$ in. in diameter.

Sec. 18—Materials *

18.1. *Pressure castings (main castings).* On meters in sizes up to and including 2 in., main casings shall be made of a copper alloy containing not

* The composition of all alloys in this section is subject to commercially accepted tolerances.

less than 75 per cent copper. On meters larger than 2 in., main casings shall either be of a copper alloy containing not less than 75 per cent copper or of cast iron protected by a corrosion-resistant coating or other anticorrosion treatment.

18.2. *Register box rings and covers.* On meters in sizes up to and including 2 in., register box rings and covers shall be made of a copper alloy containing not less than 75 per cent copper. On meters larger than 2 in., register box rings and covers shall be either of a copper alloy containing not less than 75 per cent copper or of cast iron.

18.3. *Measuring chambers.* Measuring chambers shall be made of a copper alloy containing not less than 85 per cent copper and suitable amounts of tin, lead, and zinc.

18.4. *Measuring pistons or discs.* Measuring pistons or discs shall be made of vulcanized hard rubber having sufficient rigidity and strength to operate at the rated capacity of the meter. They shall have sufficient dimensional stability to retain operating clearance at working temperatures up to 80°F and shall not warp or deform when exposed to a temperature of 100°F.

18.5. *Measuring chamber diaphragms.** Measuring chamber diaphragms shall be made of monel, phosphor bronze, stainless steel, or hard rubber.

18.6. *Piston spindles, thust rollers, and thrust roller bearing plates.** Piston spindles, thrust rollers, and thrust roller bearing plates shall be made of monel, phosphor bronze, stainless steel, or hard rubber.

18.7. *Intermediate gear trains.* Frames and gears of intermediate gear trains shall be made of a copper alloy containing not less than 75 per cent copper and suitable amounts of tin, lead, and zinc. Pinions shall be made of copper alloy containing not less than 60 per cent copper.

18.8. *Bottoms (breakable).* Breakable bottoms (frost bottoms) shall be made of cast iron or bronze of such design and composition as will satisfy the break or "yield" requirements set forth in Sec. 6.

18.9. *External fasteners (case bolts, nuts, screws, and washers).* All external fasteners for meters in sizes up to 1 in., if the fasteners are cast parts, shall be of the same composition as the meter casing (Sec. 15.1). Fasteners made from rolled mill stock shall be made of copper bearing alloy containing not less than 57 per cent copper or of stainless steel. On meters larger than 1 in., casing bolts, washers, and nuts shall be made of a copper alloy containing not less than 57 per cent copper or of iron or steel treated to resist corrosion.

18.10. *Coupling tubes and nuts.* Coupling tubes and nuts shall be made of a copper alloy containing not less than 57 per cent copper.

18.11. *Companion flanges.* Companion flanges shall be made of cast iron.

Sec. 19—Registration Accuracy

The quantity registered on the meter dial shall be not less than 98.5 per cent and not more than 101.5 per cent of the water actually passed through the meter while the meter is being tested at any rate of flow within the normal test flow limits specified in Table 1 with water at a temperature less than 80°F. Not less than 95 per cent of the actual flow shall be recorded when a test is

* The life of materials used for these meter parts is dependent upon the materials used for other associated parts. The purchaser should not make specific designations without first consulting the manufacturer.

made at the minimum test flow rate set forth in Table 1 with water at a temperature less than 80°F.

Sec. 20—Pressure Requirement

Meters supplied under this standard shall operate without leakage or damage to any part at a working pressure of 150 psi.

Sec. 21—Workmanship and Materials

Meters shall show no defects in materials or workmanship for a period of one year from date of shipment. The manufacturer shall replace, without charge, those parts in which a defect has developed within a year of shipment upon their return to the manufacturer or upon proper proof of a defect, except that this warranty shall not apply if the meter has been modified by the use of replacement parts not made by the manufacturer of the meter.

Sec. 22—Rejected Meters

The manufacturer shall, at his own expense, replace or readjust all meters rejected for failure to comply with this standard.

Notes

The following notes are not to be considered part of AWWA Standard C700. They are given only for purposes of information.

1. Units of Measurement

Approximately half of the water meters in use in the United States register in US gallons and half in cubic feet. This situation makes it extremely difficult to effect standardization. It is recommended, however, that US gallons be acknowledged as the preferable unit of measure and that, whenever possible, US gallons be established as the standard unit.

2. Register Types

Water meter registers may be of the straight-reading or round-reading types. The round-reading type is more often misread, and the problem is further complicated if more than one make of meter is used in a single water system. It is also more difficult to print postcards for customer reading where two or more makes of meters with round-reading registers are used. It is recommended, therefore, that the straight-reading type of register be adopted to eliminate these difficulties.

3. Tests

3.1. *Capacity and pressure loss tests.* Capacity tests are tests of the design of a meter. When a meter of a given design has once been tested for capacity, it should not be necessary to test others of the same type unless a change has been made in design. The capacity test should be made with two identical piezometer rings of the same diameter as the nominal size of the meter being tested. The piezometer rings must be free from any burrs where the holes are drilled through the wall of the ring, and no fewer than four holes should be provided, drilled in pairs on diameters at right angles to each other. The inlet ring should be set close to the meter at a distance of eight diameters or more below the nearest upstream stop valve or fitting, and the outlet ring should be placed 8–10 diameters from the outlet of the meter. The diameter of the inlet and outlet pipe should be the same as the nominal size of the meter to be tested. The rings are to be connected to a mercury U-tube by rubber or metallic tubing, and equipped with an accurate adjustable scale for measuring the difference in mercury level. Provision should be made for the complete removal of air from the U-tube and tubing, and the installation should be such that air will rise to the air outlets. If measurements are to be made at relatively high flow rates, it is necessary to read both sides of the mercury column simultaneously in order to compensate for irregularites in the diameter of the glass U-tube, and to avoid errors due to fluctuations.

3.2. *Pressure tests.* A pressure test should be made on each size of a particular design of meter furnished. The test pressure should be 150 psi, which may be produced by use of a hand pump or any other available device. The meter should be tested for accuracy before and after it has been pressure tested to determine whether there has been any distortion that could affect the registration. If satisfactory results are obtained, it is unnecessary to make more than one pressure test on each size of a given design of meter.

3.3. *Accuracy tests.* All meters should be tested for accuracy of registration in accordance with AWWA C705, "Recommended Procedure for Testing Cold-Water Meters," which recommends the test flow rates and test flow quantities given in Table A.

If the purchaser does not have suitable means for testing, the manufacturer should be requested to furnish a certificate showing that each meter has been tested for accuracy of registration and that it complies with accuracy and capacity requirements of AWWA C700.

If it is considered necessary by the purchaser to avoid having meters register in excess of 100 per cent *at the maximum rate of flow* during normal periods of service, new meters should be obtained which register not more than 98.5–99 per cent at maximum flow rate when new. This allowance will provide for the slight increase in registration due to the buildup which occurs with most waters. Excessive buildup normally causes friction between the piston and measuring chamber with resultant lowering of accuracy. Registration of displacement type meters is closely controlled by the design and close tolerances of manufacture. Registration increases more than 1.5–2 per cent above the original calibration are rarely experienced.

All meters, until recent years, were equipped with a set of replaceable change gears for effecting changes in registration. Certain types of displacement meters now being produced are not equipped with removable change gears. In such meters, other means for correcting inaccuracy of registration must be utilized.

TABLE A

*Recommended Accuracy Test Flow Rates and Quantities**

Size in.	Maximum Rate			Intermediate Rate			Minimum Rate		
	Rate of Flow gpm	Test Quantity		Rate of Flow gpm	Test Quantity		Rate of Flow gpm	Test Quantity	
		gal	cu ft		gal	cu ft		gal	cu ft
⅝	15	100	10	2	10	1	¼	10	1
¾	25	100	10	3	10	1	½	10	1
1	40	100	10	4	10	1	¾	10	1
1½	80	1,000	100	8	100	10	1½	100	10
2	120	1,000	100	15	100	10	2	100	10
3	250	1,000	100	20	100	10	4	100	10
4	350	1,000	100	40	100	10	7	100	10
6	700	1,000	100	60	100	10	12	100	10

* Registration accuracy limits set forth in Sec. 19, AWWA C700, are 98.5–101.5 per cent for maximum and intermediate rates, and 95 per cent for minimum rates.

4. Testing Equipment

The measuring device used to determine the amount of water discharged in testing should be preferably of volumetric type, designed to provide accuracy of measurement within 0.25 per cent of the actual quantity. Test by weight is satisfactory, however, if the scales are kept accurate.

5. Under- and Overregistration

In a displacement meter, the motion of the piston is transmitted by a system of gearing to the register which records the flow in convenient units of measurement. The

gearing translates the motion of the piston into the unit of measure indicated by the register. The registration is thus directly dependent on the number of nutations or oscillations of the piston. The registration is a true measure of flow only when the meter has been properly calibrated. After proper calibration the meter will continue to register correctly only so long as the piston continues to make the proper number of cycles for each unit of quantity passed through the meter. If any condition should develop whereby the piston is compelled to make fewer than the proper number of cycles per unit of quantity passed through it, the meter will underregister. If the piston is compelled to make more than the proper number of cycles, the meter will overregister. Under ordinary working conditions, a number of factors may cause under- or overregistration after comparatively short intervals. The more important of these are excessive wear, extreme temperatures, corrosion, and material in suspension.

TABLE B

Average Recommended Intervals Between Meter Tests

Meter Sizes in.	Interval Between Tests *years*
$\frac{5}{8}$	10
$\frac{3}{4}$	8
1	6
$1\frac{1}{2}$	4
2	4
3	3
4	2
6	1

5.1. *Excessive wear.* Excessive wear of the moving parts of the meter may be caused by improper setting, by over-speeding, or by the selection of a meter too small for the work required. The effects of excessive wear of the piston or measuring chamber are slippage and underregistration. Excessive wear of the intermediate gear train may cause the gears to slip or to bind. In either case, if the meter does not stop entirely, underregistration will result. To avoid excessive wear, meters should be set in a horizontal position and should not be run at destructive speeds. The capacities given for meters in Table 1 of C700 are the maximum rates of flow at which water should be passed through the meters for short periods of time. They are the peak loads which the meters should undergo only at long intervals and would be destructive if continuous. For continuous 24-hr service, meters of the displacement type should not be operated at flows greater than one-third of their rated capacity.

5.2. *Temperature extremes.* Cold-water meters are not affected by temperatures up to about 80°F. In warm climates, where the temperature of the water is likely to exceed 80°F, meters with slightly larger measuring chamber clearances than usual should be used, and the accuracy limits set forth in Sec. 19 of AWWA C700 must be modified accordingly.

High temperatures can cause expansion of the rubber pistons and create unusual friction or bind the piston in its chamber. The result is slippage and underregistration or complete stoppage of the meter. Low temperatures have no noticeable effect on the working parts of the meter, although freezing will stop the meter and may cause damage.

To avoid troubles caused by temperature extremes, meters should be set at locations where they will be protected from heat and frost. At locations where hot water from heating systems may be forced back through the meter, a check valve and pressure-and-temperature relief valve should be installed on the outlet side of the meter.

5.3. *Corrosion.* All the metals used in the construction of a meter are affected by the corrosive action of water, although the action is very slow with most potable waters.

It should be recognized, however, that when meters are used in highly aggressive waters, it may be necessary to use materials that are more resistant to attack. The solution of the corrosion problem requires a high degree of experience and knowledge, and the manufacturer should be consulted under such circumstances for assistance.

5.4. *Material in suspension.* Foreign material carried in suspension has a tendency to fill the space between the piston and measuring chamber and cause overregistration. Such overregistration is limited, however, and generally cannot exceed 3 per cent.

Meters provided with strainers will retain the larger particles in suspension, but the strainer will soon become clogged if the water is not kept reasonably free from sus-

pended matter. Sand is especially destructive, and care should be exercised to keep sand from reaching the pipes supplying the meter.

6. Periodic Tests

Meters properly selected as to size and type will give satisfactory service over a long period of time without attention only if operated under ideal conditions. Under ordinary conditions, meters must be given some care if they are to function properly. In most cases, it is impossible to ascertain, without actual test, whether a meter in service is registering with the required degree of accuracy. Consequently, to insure reliable meter measurements, it is essential that all meters be subjected to periodic tests. The interval between tests and the method of conducting them must be governed largely by local conditions. Many state regulatory commissions specify intervals between tests on both a time and quantity basis. Under *average* conditions, however, the intervals between tests should not exceed the limits set forth in Table B.

7. Meter Storage

Meters should be stored in a location not subject to unduly high or low temperatures, those with oil-enclosed gear trains should be stored in an inverted position to avoid possible seepage of oil into the measuring chamber.

Prepared by AWWA Committee 8610 D

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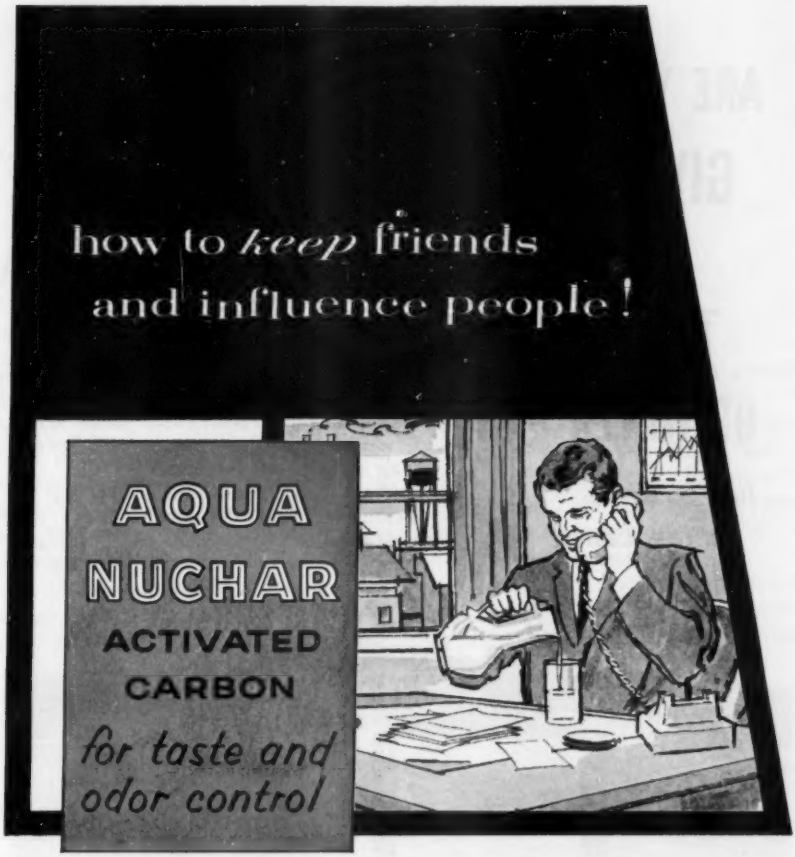

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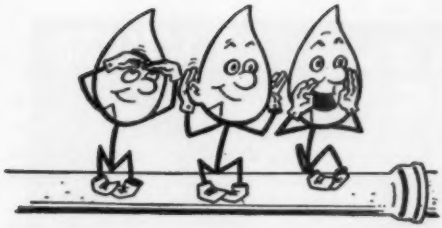


Percolation and Runoff

Quality and quantity were rampant at Detroit last month—quality being the theme and quantity supreme as AWWA's 81st Annual Conference hung up records for everything. Not only were there more registrants on hand than ever before—3,691 compared with San Francisco's 3,211—but there were more men more than even that, with 3,034 compared to a previous record of 2,426. And all these more had more to do in more room than ever before as the program and facilities of the meeting were not only more but more better.

It was Detroit's new $54,000,000 municipal auditorium, Cobo Hall, that set the tone of more and better, providing a setting of incomparable space, beauty, comfort, and convenience for conference activities. There, there was no end of room for the exhibits, no end of rooms for the meetings and entertainment, and not even room for end complaints, as every seat was comfortably cushioned.

The 15-session technical program worked out by Shaw Cole and his committee drew bigger crowds and better discussions than ever before. And such stars of the show as Senator Robert S. Kerr, on national water resources; Reclamation Commissioner Floyd E. Dominy, on the Upper Colorado River project; Harry P. Lowe, on the Corps of Engineers plans for providing water on the moon; Rolf Eliassen, on the prospects and place of desalinization; and Milton Redlich, on the banker's interest in water supply, provided the glamor to point up the technical presentations of a hundred other speakers.

All during the week committee meetings competed with technical sessions for the attention of the record crowds as more than 30 of AWWA's committees got together to work. And the Association's Executive Committee put in 11½ hr and the Board of Directors, 10 hr in session on AWWA business. Approved during these latter sessions was the employment of the management consultant originally proposed by the Aims & Objectives Committee and recommended by the Board's Steering Committee.

Entertainment, under the skilled and ambitious direction of Gerry Remus and his chief assistants Herschel Self, Ted Vander Velde, Ned Barrett, and Henry Tiedeman, was as oustanding as everything else. Beginning with a Meet & Greet affair that attracted record crowds on Sunday night, the social program set attendance and enjoyment records in every event. At the Awards function on Monday night, these:

(Continued on page 36 P&R)

(Continued from page 35 P&R)

Honorary Members: RAY L. DERBY, OTTO E. ECKERT, ATTMORE E. GRIFFIN, and FRED MERRYFIELD

Diven Medalist: LEWIS S. FINCH

AWWA Publications Awardee: CLAUD R. ERICKSON

Division Awardees: Distribution—ROBERT F. MCCAULEY; Management—WILLIAM R. SEEGER; Purification—J. L. TUEPKER and H. O. HARTUNG; Resources—LOUIS KOENIG

LaDue Safety Awardees: Class 1—STILLWATER, Minn., BOARD OF WATER COMMISSIONERS (Herbert S. Grove, Gen. Mgr.); Class 2—SAN DIMAS-CHARTER OAK DOMESTIC WATER CO., San Dimas, Calif. (William P. Crum, Secy.-Mgr.); Class 3—PACIFIC GAS & ELECTRIC CO. WATER SYSTEMS, San Francisco, Calif. (John N. Spaulding, Gen. Supt.)

All-AWWA Advancement Awardee: GRIFFIN (Ga.) WATER DEPT. (Lewis R. Simonton, Supt.)

together with 29 Fuller Awardees took their bows before the President's Reception and Ball. Then on Tuesday, AWWA opened Detroit's new Convention Arena with a full scale carnival that drew a crowd estimated at 4,000 registrants and guests. And on Thursday, in the very grand ballroom of Cobo Hall more than a thousand were on hand for the Annual Banquet & Ball, to salute President Caesar Wertz for a year of great accomplishment and to greet President John Cramer and his promise of more progress to come.

Businertainment, on the other hand, was how the Fuller Award Breakfast was classified, as Jim Harding, Fuller friend and Fuller awardee, presented an intimate and entertaining picture of the prodigious AWWAer whom the award honors, and John Murdoch was elected 1961–62 chairman of the Fuller Award Society in a characteristic chorus of "nyets."

There was a golf tournament, too, but as of this writing none of the winners of WSWMA's potful of prizes, nor even the scores, has yet been reported—only the fact that almost a hundred dubs and pros of both sexes stormed the Hillcrest Country Club in Mt. Clemens with nigh onto 10,000 shots.

Meanwhile, the ladies were taking care of themselves, under the very capable and hospitable hands of Mrs. Gerry Remus and her lieutenants Mrs. Henry Tiedeman and Mrs. Robert Blair. With a beautiful headquarters at Cobo Hall, the ladies took off in all directions to breakfasts, lunches, fashion shows, and tours of Detroit's Art Center, Cranbrook, Greenfield Village, and Henry Ford Museum.

And when anyone wasn't too busy at something else, the record exhibit, in which 101 manufacturers and suppliers loaded 187 booths with the newest and best equipment in the field, reached out to attract them. And attract them it did, for WSWMA manager John Stewart reported the best attendance ever at the shopping end of the show.

All this activity had as its purpose an emphasis on quality—quality water and quality water service. That was the theme of the meeting and that was the thought carried away by all who were on hand to participate in this 81st and biggest and best of AWWA's annual conferences.

"Its 81st forever, but its biggest and best only until next year," promises Sam Baxter, who already has his Philadelphia convention management committee under way on plans for facts, fellowship, and fun for four thousand at Philadelphia, June 17–22, 1962.

(Continued on page 38 P&R)

BISMARCK, N.D. modernizes and enlarges its filter plant with INFILCO equipment

In 1942, the City of Bismarck doubled the size of its water treatment plant to a capacity of 4.5 MGD to clarify, soften and stabilize Missouri River water. In 1958, current needs required a further 100% plant expansion. Future demand was estimated and the Consulting Engineers for the city designed a new plant of 6 MGD capacity.

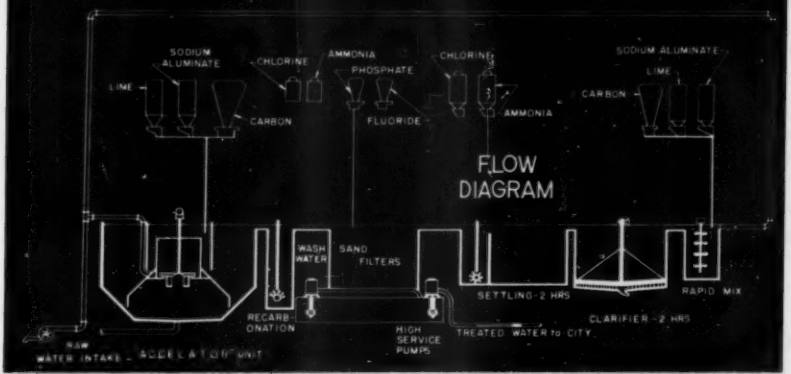
The new plant includes an ACCELATOR® unit, INFILCO meters, "TWIN THROAT" venturi tubes, Chemical Feeders and VISCO-MATIC® slaker, C.-A.-P. SYSTEM® filter controls, a Type "P" Recarbonator and three non-valve INFILCO filter operating consoles.

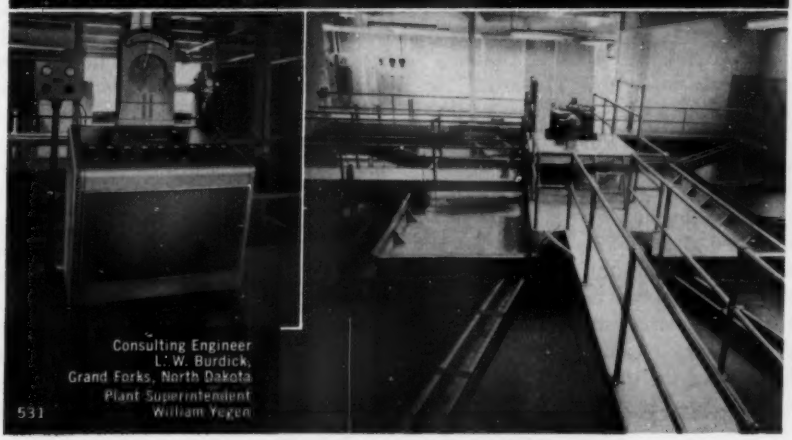
The old plant was modernized by converting hydraulic filter control equipment to pneumatic operation with automatic shut-off from clearwell level, using six new C.-A.-P. SYSTEM consoles, INFILCO Loss-of-Head and Rate-of-Flow converters, controllers and gauges.

INFILCO INC.
General Offices: Tucson, Arizona

INFILCO GENERAL

Field offices throughout the United States and in other countries.
Subsidiary of General American Transportation Corp.





Consulting Engineer
L. W. Burdick,
Grand Forks, North Dakota
Plant Superintendent
William Yegen

531

(Continued from page 36 P&R)

Like Ike, like Caesar—and now like even JFK—presidents will play golf and presidential prerogative prevent publicizing their proficiency. When Ike became a private citizen again last winter, we expected to have our curiosity soon satisfied, but then his generality was restored and what had been a state secret became a military one. As far as Caesar Wertz is concerned, however, now it can be told—and, now, with a new set of clubs that was presented to him as a stepping-down gift by AWWA, there should, we are told, be plenty to tell.

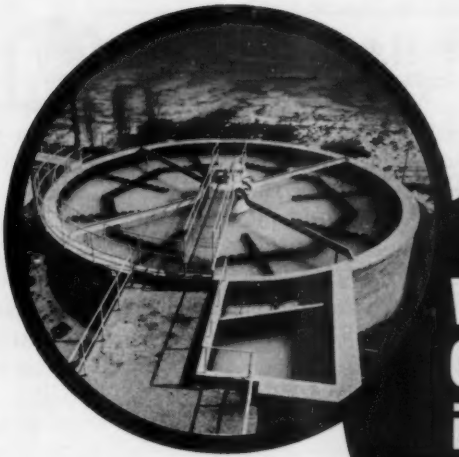
We were curious, though, to learn why, after, well, more than a few years of golf, Caesar should suddenly *need* clubs. A then friend of the then president then told us—and, of course, we promised not to tell. We can properly point out, however, that the need became desperate last April Fool's Day during a tournament at the Palmetto Country Club near Miami, a course that is noted not only for the number (13), but for the depth (25 ft or more) of its water hazards. Observing the proprieties, we'll say no more of Caesar's score than that, coming up to the twelfth green, he wasn't even in competition for the prizes of the day, for "Most Balls out of Bounds," "Most Balls in Water Hazards," or "Most Putts." And on the twelfth he really belted one—in fact, he thought, a little too far. So he hurried anxiously aboard the electric cart and sped to the spot where his ball had approached the water. At the scene, he and his partner jumped out to hunt in the long grass in the hope that the ball had, perhaps, stopped—and that was how Caesar came to win the special award of the day, for "Most Electric Carts in the Water."

When last seen, the car, with two bags of clubs and various other paraphernalia, including two sets of eyeglasses, was headed straight down. And the boys who later dove for the clubs and glasses, as well as the crane operator who finally fished out the cart, verified that it had reached the *very* bottom of the 30-ft pit. And, most unfortunately, the ball that Caesar hit had rolled into the hazard. So he had to drop another ball and take a two-stroke penalty, not to mention using the opponents' clubs, to finish the round. It simply isn't true, though, that Caesar threw the cart in. After all . . . well, after all, they do weigh a thousand pounds or more.

Salt water daffy the nation continues if our burgeoning pile of newspaper and magazine clippings is any clue. As every mention of water supply problem is a boost to the cause of public interest in, if not public understanding of, public water supply, we are loathe to complain as long as water works men are not caught up in the daffiness to a point where they decide to wait for the panacea instead of doing something about their problems now.

The federal government, whose Office of Saline Water has done more than any other agency to stir up this surge of interest in water, is still hard at the task, with even President Kennedy getting in a lick at every opportunity. In May, the opening of full-capacity tests at the first of the government's demonstration plants, that will eventually serve water to Freeport, Tex., and a Dow Chemical Co. plant near there, provided a new batch of water supply news, as did the groundbreaking for the demonstration plant at Webster, S.D. And Interior Secre-

(Continued on page 40 P&R)



Why General Filter is EVERYWHERE

Everywhere in the nation you'll find General Filter water and waste treatment equipment giving complete satisfaction to municipalities and industries. Here's why: **DEPENDABILITY** — the result of more than twenty years' experience in building quality water process equipment. **ECONOMY** — proved by long life and trouble-free operation of General Filter plants. **SERVICE** — by 45 sales offices and 36 field service departments coast-to-coast. There are many other reasons why it pays to specify General Filter. Write for complete information, bulletins and free estimates.

GENERAL FILTER CO.

WATER PROCESS EQUIPMENT AMES, IOWA

AERATORS • FILTERS • SOFTENERS • CLARIFIERS
FLASH MIXERS • FLOCCULATORS • PNEUMATIC CONTROLS
ROTARY DISTRIBUTORS • SLUDGE SCRAPERS

(Continued from page 38 P&R)

tary Stewart Udall was setting up free drinks—of Gulf of Mexico water—in Congress.

Meanwhile, industry, too, has put its shoulder to this wheel of the water wagon and is pushing hard through both advertising and newsmaking. The list of companies whose mouths have been salt watering of late include:

American Machine & Foundry Co., whose AMFion ion-permeable membrane system had been incorporated in a home unit called "Aquafresh," that was being test marketed at Midland, Tex., where the unit, which converts up to 30 gpd of brackish water, was being rented at $7.95 per month.

Blaw Knox, Inc., which has suggested the use of butane as both refrigerative and melting agent in a freezing method for salt removal.

Bogue Electric Mfg. Co., whose fully automatic demineralization system has been adapted to desalt brackish water for drinking purposes in a process now being used to supply water for 300 military personnel on Matagorda Island.

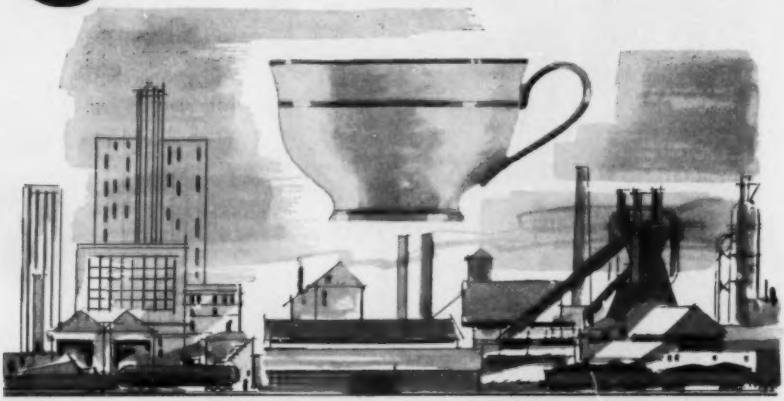
Carrier Corp., whose freezing system is being considered as the basis

Roger E. Risley (left), vice-president and director of engineering, Dresser Mfg. Div., Dresser Industries, Bradford, Pa., was sworn in on May 26 as assistant director for mobilization planning of the Water and Sewage Industry and Utilities Div., BDSA, by Acting Administrator Thomas E. Drumm Jr.

(Continued on page 44 P&R)

MH

Roll-call for water



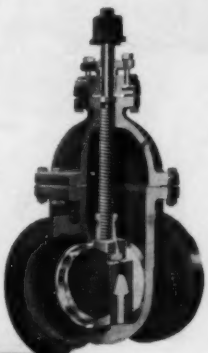
a CUP of WATER

Because until recently it always was available, a cup of water here has been considered a "little thing." Today, we suddenly realize that many water facilities are deficient . . . and a "cup of water" in some places no longer is a little thing!

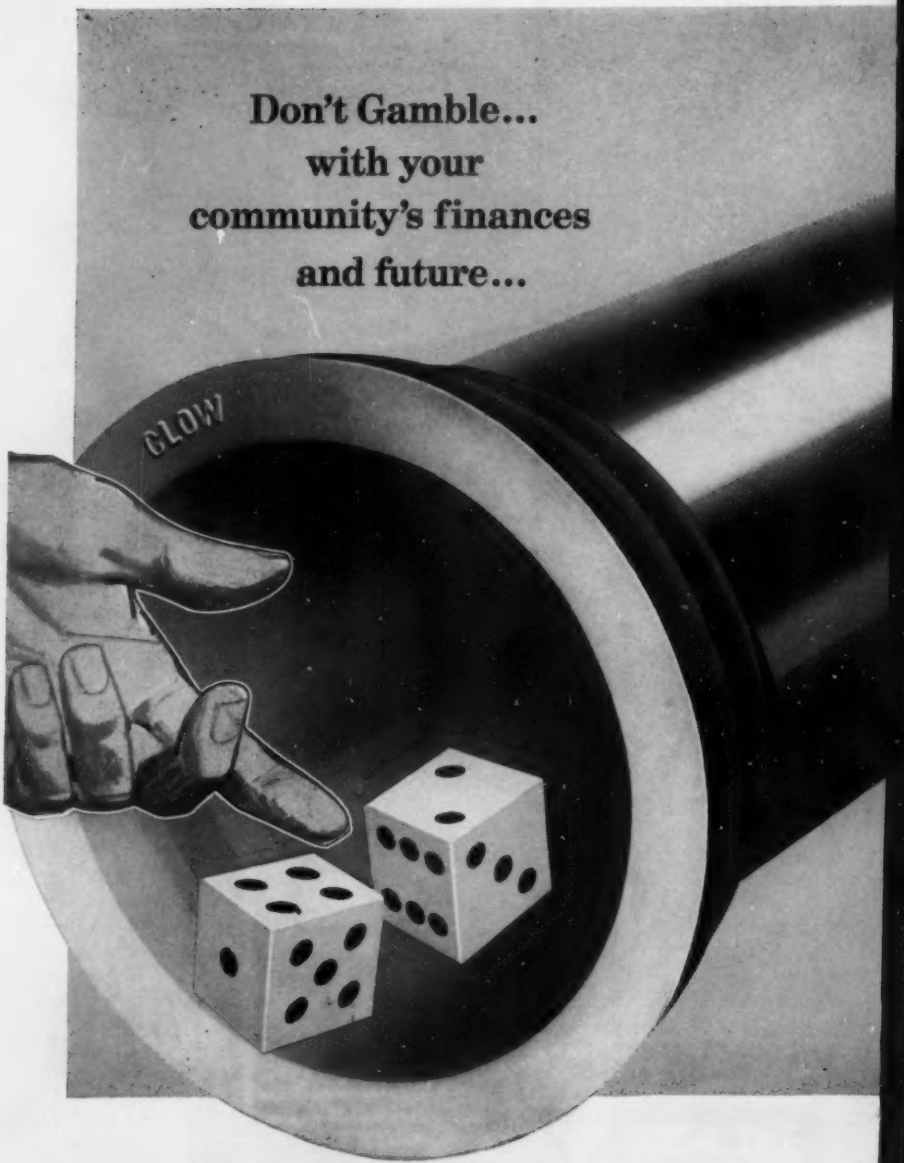
Of the total population, 26.6 per cent or approximately 25 million citizens of the U.S.A., definitely have inadequate water supply.* In addition water supply is uncertain for 23.2 per cent of the population or nearly 21 million more. Only 50.2 per cent of the population, or approximately 45 million people, enjoy adequate water service. Of 587 water works systems, serving 25,000 population or more each, service is inadaquate or uncertain in 255 of them! The U.S. Department of Commerce estimates that water supply facilities within the next 20 years will need to be doubled.

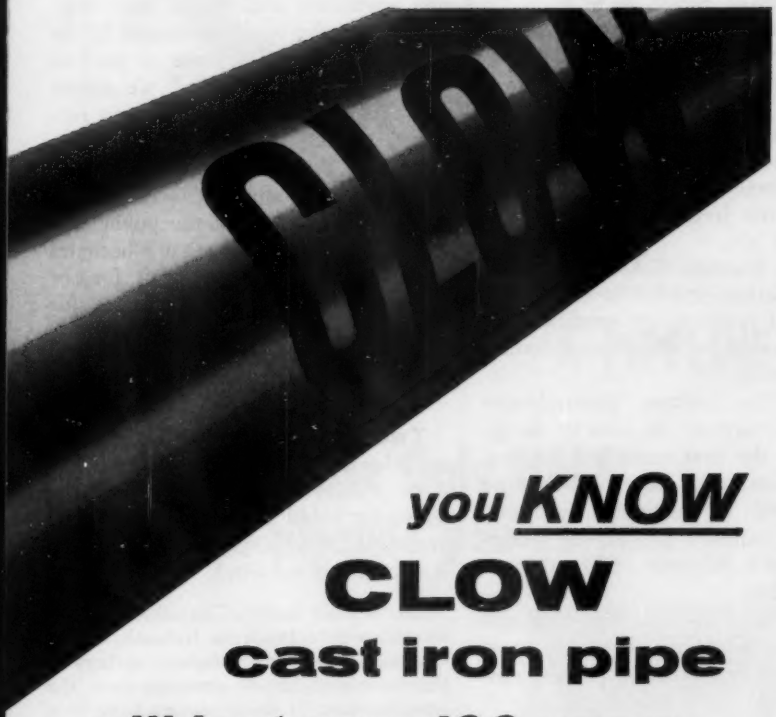
Municipal and utility officials know this situation but in many cases need better public support before they can make a move. In future advertisements, we will attempt to sketch brief facts about the water shortage of particular groups of states.

*Survey by Water and Sewerage Industry and Utilities Division, Business and Defense Services Administration, U.S. Department of Commerce, Washington, D. C.



M&H VALVE
AND FITTINGS COMPANY
ANNISTON, ALABAMA


Don't Gamble...
with your
community's finances
and future...
GLOW



you KNOW

CLOW

cast iron pipe

will last over 100 years

Can you risk the high cost of buying substitutes "at a price"? CLOW cast iron pipe assures dependable water service... now and for the future. The first cost is the *last* cost. Only tough, rugged cast iron pipe combines proven long life, trouble-free service, and sustained high-carrying capacity at low cost. Can you afford to buy less? Before you buy, let us prove to you that CLOW cast iron pipe is the best value for your job.

CLOW manufactures a complete line of cast iron pipe, fittings, valves, fire hydrants and piping specialties for every waterworks installation. Write or call today.

CLOW CAST IRON PIPE

JAMES B. CLOW & SONS, INC.
201-299 North Talman Avenue, Chicago 80, Illinois

Subsidiaries:
Eddy Valve Company, Waterford, N.Y.
Iowa Valve Company, Oskaloosa, Iowa

Clow Cast Iron Pipe Plants are located at
BENSENVILLE, ILLINOIS • BIRMINGHAM, ALABAMA • COSHOCTON, OHIO

(Continued from page 40 P&R)

of the demonstration plant to be built at Wrightsville Beach, N.C.

E. I. du Pont de Nemours & Co., which has an interest in a solar distillation system now being tested in Florida.

Fairbanks Whitney Corp., which has broken ground for a 250,000-gpd plant at Elath, Israel, to give the well publicized Zarchin freezing process a full-scale plant test.

General Electric Co., whose thin-film distillation process is claimed to have broad potential for municipal, as well as marine, industrial, and domestic application.

Ionics, Inc., whose permselective membrane method is already in operation in the first municipal application at Coalinga, Calif. A similar method will be employed by Asahi Chemical Industry Co. at the federal government's Webster, S.D., demonstration plant.

Struthers Wells and the Scientific Design Co., who have combined forces to develop a new freezing process purported to cut costs sharply.

Westinghouse, which is building what is advertised as "the country's largest sea water plant at San Diego to provide 7,000,000 gal of 'new' drinking water a week"—in contrast, we started to day, with a paltry 1 mgd by the new Freeport plant, but, of course, who can deny that it will be "the country's largest sea water plant at San Diego."

With all this effort and talent concentrated on the problem, we can indeed look forward to a not-too-distant day when sea water or brackish water will merit consideration as an alternative source of fresh-water supply in a growing number of communities. Meanwhile, although Westinghouse also advertises and others have suggested that the water produced by its plant will be "twelve times as pure as the city's present supply," we rather doubt that desalted water, without further treatment, will win any popularity contests as far as palatability or vitality, or even, plumbing, is concerned. And we can hope that the public will not be taken so far asea that *it* becomes content to sit back and wait for, or perhaps even to make sacrifices for twelvefold purity as against quality water that is within its reach now undistilled!

Two glasses of water caught our attention in a recent full-page ad in the *New Yorker* magazine. "One," the ad said, "holds a beauty secret 2,000 years old. Which?" And the "which," it appears, is no witch. At any rate:

> One is plain water. The other is water blessed with a touch of Nature's magic. It comes from certain thermal springs of France where for 20 centuries even the grandmothers in these regions have been noted for smooth and flawless skin. What mysterious quality is found in these living waters? A unique natural plankton, formed of tiny primal organisms, rich in minerals, vitamins, and substances approximating those found in healthy human skin. Our beauty-wise biochemists have found a way to extract this natural phenomenon and blend it into the penetrating cremes and lotions of Biotherm cosmetics, to help keep your skin looking forever more beautiful. Regardless of age, your skin can seem "re-born" . . . as though you lived at spring-side!

Except for the fact that the "fabulous concentrate of the potent life-source . . . cannot be made synthetically" and that an introductory kit sells for $10

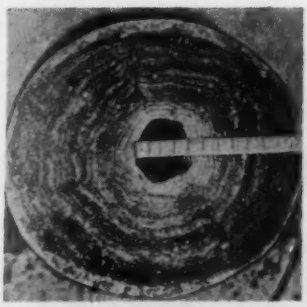
(Continued on page 46 P&R)

YOU WOULDN'T BUILD JUST HALF

A PIPELINE

So Why Use Only HALF of the pipeline you've got!

Neglected city and industrial water pipes fill with deposits like the picture on the right . . . cut down service, and increase fire insurance rates. No half-way methods will cut these rock-hard deposits . . . it takes Ace's modern power equipment. And Ace doesn't merely open the lines . . . they clean them thoroughly, restoring them to their original capacity, at less cost to you. Investigate now!



CALL COLLECT . . . CHestnut 1-2891

CUSTOM-BUILT EQUIPMENT HANDLES ANY JOB, LARGE OR SMALL

ACE

Ace PIPE CLEANING, INC.

4000 East Truman Road, Kansas City 27, Missouri

(Continued from page 44 P&R)

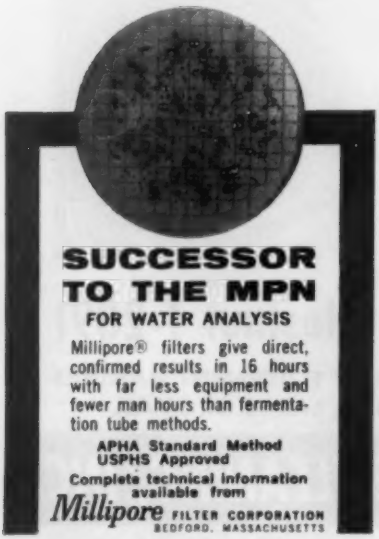
plus tax, no further clues to which glass holds the beauty secret are given.

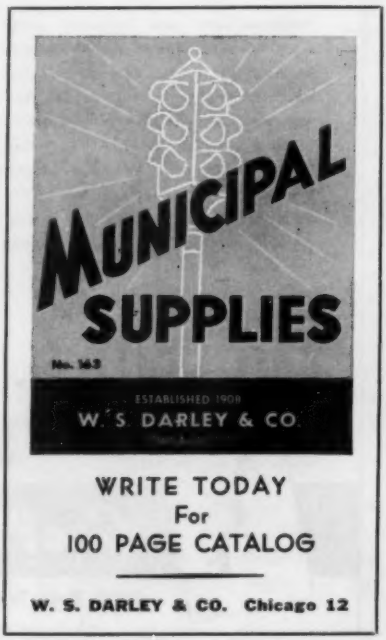
Make ours plain water we say, and if our wife really wants plankton we know where we can get her a pussful for free whenever she wants to look like a French grandmother.

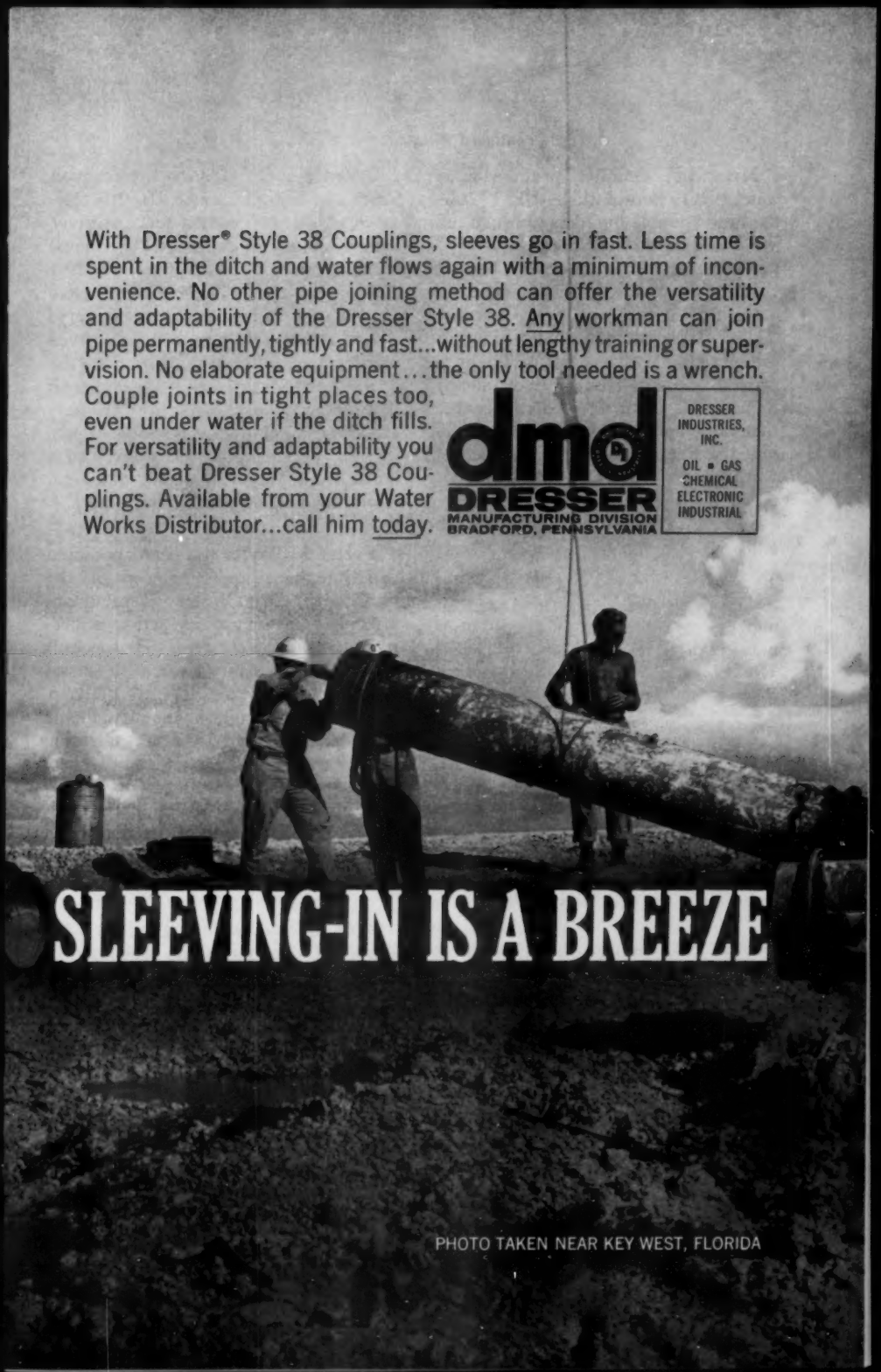
"Foul tirade," anagrammatically speaking, is synonymous with "fluoridate," and, ungrammatically speaking, we can point out that often that ain't the only way. But by now even the tirades have none of the startling originality of the early days and the arguments in favor of fluoridation are repetitiously dull—except, that is, to those who are directly involved. Where fluoridation is an issue, of course, the same old facts, arguments, and allegations come to life again and command just as much newspaper space, just as much emotional involvement, and just as much apprehension and misapprehension as always.

One of the new antifluoridation tracts that was receiving considerable attention recently was called "A Petition From Beatitude," the story of a fictitious community which presumably carried the chemical treatment of water supply for physiological benefit to its logical extremity. Then the fact that Robert Welch, the owner and publisher of the magazine in which the article appeared, was identified as the organizer of the John Birch Society somewhat dampened its popularity.

(Continued on page 48 P&R)


SUCCESSOR
TO THE MPN
FOR WATER ANALYSIS
Millipore® filters give direct, confirmed results in 16 hours with far less equipment and fewer man hours than fermentation tube methods.
APHA Standard Method
USPHS Approved
Complete technical information available from
Millipore FILTER CORPORATION
BEDFORD, MASSACHUSETTS




With Dresser® Style 38 Couplings, sleeves go in fast. Less time is spent in the ditch and water flows again with a minimum of inconvenience. No other pipe joining method can offer the versatility and adaptability of the Dresser Style 38. Any workman can join pipe permanently, tightly and fast...without lengthy training or supervision. No elaborate equipment... the only tool needed is a wrench. Couple joints in tight places too, even under water if the ditch fills. For versatility and adaptability you can't beat Dresser Style 38 Couplings. Available from your Water Works Distributor...call him today.
dmd
DRESSER
MANUFACTURING DIVISION
BRADFORD, PENNSYLVANIA
DRESSER INDUSTRIES, INC.
OIL • GAS
CHEMICAL
ELECTRONIC
INDUSTRIAL
SLEEVING-IN IS A BREEZE
PHOTO TAKEN NEAR KEY WEST, FLORIDA

(Continued from page 46 P&R)

Meanwhile, definitely profluoridation was PRO fluoridation—PRO being the new "double duty" toothbrush, impregnated with "stannous fluoride, 2 per cent by weight, in every bristle."

Rather neutral to us seemed the news that within the next year secondary calcium phosphate dihydrate or synthetic hydroxyapatite might be proved more effective than sodium fluoride in control of decay, except that these solutions were already being billed as "harmless" by the biochemists working on them at the University of Alabama Medical Center.

And just plain confusing was the editorial statement in the Newark (N.J.) *Evening News* that:

> About 44,000,000 people in 3,835 communities are drinking fluoridated water now. But about 37,000,000 of them in 1,932 communities had no choice because their water comes that way naturally.

until we realized that 37,000,000 is actually the total of those who chose. Wistful thinking, we would judge from the tenor of the editorial, or else, anagrammatically, just an "aufl editor."

John Ryle retired in June as service supervisor for the Passaic Valley Water Commission, Clifton, N.J., thus ending the family's connection for more than 100 years with the Passaic Water Co. and its successors. The company was founded by his grandfather in the early 1850's. During the 1890's and 1900's, his uncle, William Ryle, was superintendent. He also served as president of AWWA in 1895. John Ryle, who started working for the company in 1904, is a Life Member of AWWA, having been a member since 1919.

Green flowed Georgia's Savannah River last Mar. 17, as all 150,000 residents of the city named for that river took a holiday to celebrate "the pious, immortal memory of St. Patrick." Not chlorophyll, though it might well have been with breath-giving parties everywhere and the fleet in, too, but green marker dye was used to Hiberniate the stream for the occasion. As Savannah is a port city, no downstream drinkers got their Irish up. In honor of his, though, President Kennedy received a bottle from Mayor Malcolm MacLean —not Scotch, of course, but water.

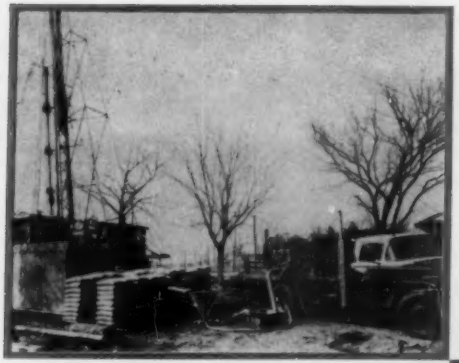
Frank S. Taylor has been appointed superintendent and engineer of the Oklahoma City Water Department, after having served as acting superintendent since February. He succeeds Morrison B. Cunningham, who served the city for 41 years (April P&R, p. 98). Taylor joined the Oklahoma City department in 1942 as a filtration engineer and became assistant superintendent in 1950.

A member of AWWA since 1941, he has been chairman of the Southwest Section and received the Fuller Award in 1954.

Hot or cold, water's good for what ails you! Boiling, it has been used by Dr. Rudolph Jaeger of Jefferson Medical College, Philadelphia, to cure 300 patients of the tic douloureux, a form of neuralgia of the facial nerve. Cold, it is being recommended by doctors as the best cure for burns.

In curing neuralgia, the technique involves the use of boiling water to induce lesions in the frontal lobes, destroying nerve cells in the gasserian ganglion, thus giving permanent relief.

(Continued on page 50 P&R)



CONTRACTORS CONSTRUCT BETTER WELLS

when Halliburton cements them!

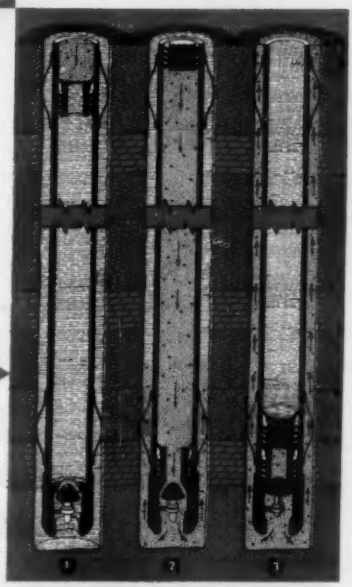
The Halliburton Jet-Type Cement Mixer permits continuous blending of dry cement with water in controlled amounts to obtain consistent water-cement ratio throughout the job.

The new well your contractor drills for you will probably be a good one . . . and *you* have to keep it that way. An important step toward continuous high yield from a water well is to construct the well *properly*. Proper construction should include cemented casing which help to provide:

- *PROTECTION from migration of contaminated water in adjacent formations, and from polluted surface water.
- *PREVENTION of bore hole cave-ins which can cut off water sources by filling the well bore or plugging the well screen.
- *ISOLATION of the aquifer to be produced.
- *PROTECTION of the exterior of well casing from corrosion.

For a better water well, get the *best* contractor . . . and to help keep your well trouble-free, longer, have him construct it properly, utilizing Halliburton's more than 35 years of experience in casing cementing.

The proven simplicity of *Halliburton's* Basic Cementing method



1. The Halliburton pump pressure forces the cement slurry into the casing behind the Bottom Plug which moves ahead of the slurry, and displaces well fluids in front of it to outside of the casing.
2. When the Bottom Plug lands in the Float Shoe, additional pump pressure ruptures the plug diaphragm, allowing the cement to pass through the end of the casing and up into the annular space between the casing and bore hole.
3. When the predetermined amount of cement has entered the casing, the solid Top Plug is inserted above it. Continued pumping of well fluid moves this plug down until it lands on the Bottom Plug, forcing the cement outside the casing. When pump pressure is released, the float valve closes, helping to prevent the cement from reentering the casing. The cement, thus held in position, sets to form a hard, permanent seal so necessary to the future protection of the well. After cement sets, the plugs are drilled out leaving the casing clear.

Dedicated through research and performance to better service for America's water wells

WATER WELL SERVICES

Halliburton
COMPANY • DUNCAN, OKLAHOMA

(Continued from page 48 P&R)

Results are said to be far better than from operative and medical therapy.

In curing burns, the technique involves running cold water over the burn until it stops hurting and repeating the treatment every time the pain returns. Although blisters form, the treatment presumably results in complete healing without scars and much less pain than otherwise experienced.

As a treat or a treatment, water is the thing!

Marsden C. Smith, formerly chief engineer of the Richmond (Va.) Department of Public Utilities, is now serving as consultant to the firm of Whitman, Requardt & Associates, of Baltimore. A member of AWWA since 1925, he is a former director (1937–40) and a recipient of the Fuller Award (1940). He is a Life Member and an Honorary Member of the Association.

High society men became three AWWA stalwarts last April—high in the American Society of Civil Engineers, that is—when AWWA past-presidents Samuel B. Morris and Abel Wolman and AWWA Life Member Thorndike Saville were selected for honorary membership in ASCE. Another AWWAer who received top honors at the Phoenix meeting of the society was Finley B. Laverty of the Los Angeles County Flood Control Dist., who was named winner of the Professional Recognition Award.

(Continued on page 52 P&R)

for Public Water Fluoridation

Sodium Silicofluoride – 99%
(Powder)

Sodium Fluoride – 98%
(Powder or Granular)

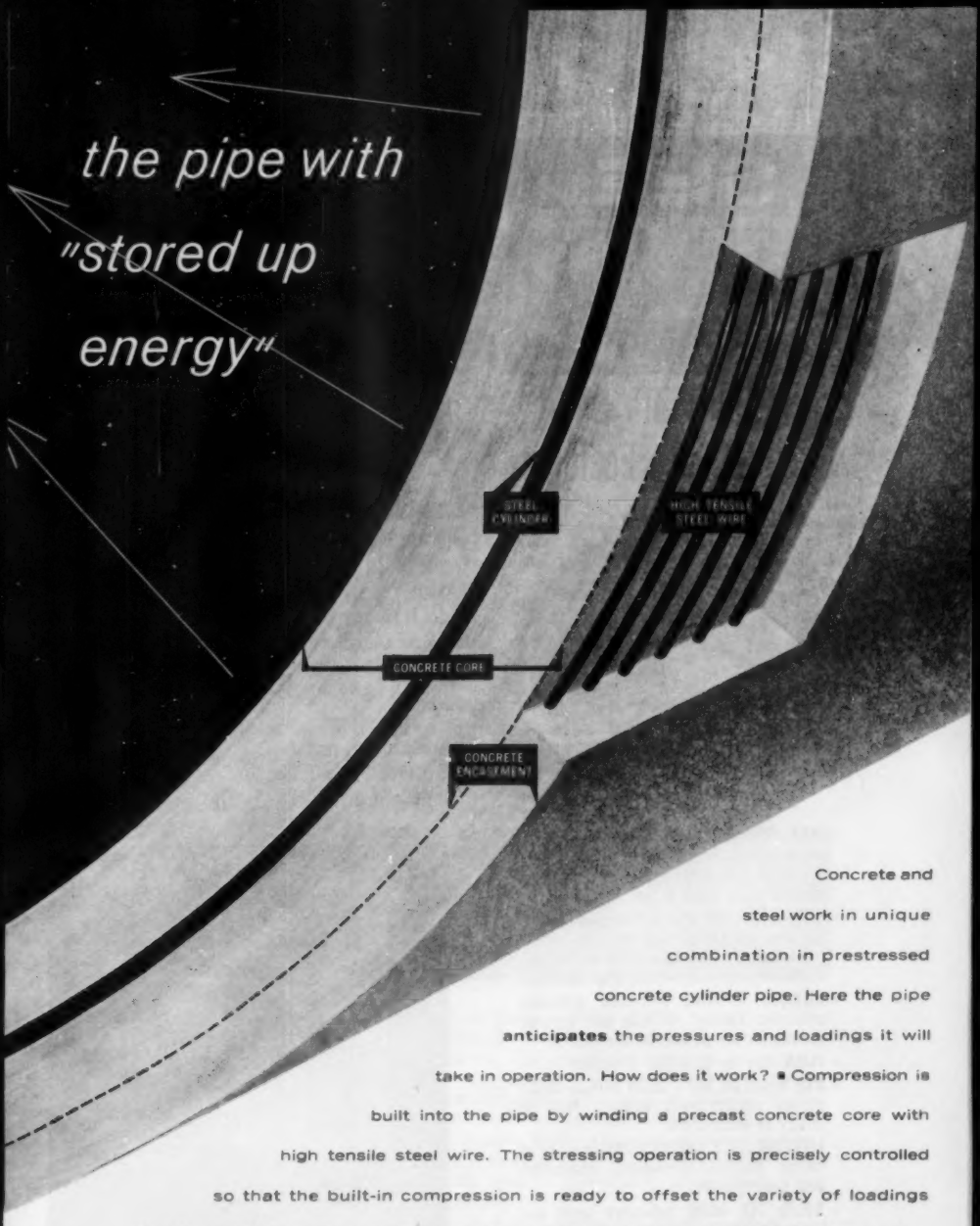
Meet AWWA specifications

White or tinted blue • Dry and free-flowing
Minimum of storage space • Available in bags and drums
Minimum of dust in handling

THE AMERICAN AGRICULTURAL CHEMICAL COMPANY
100 Church Street, New York 7, N. Y.

AA QUALITY

the pipe with "stored up energy"



Concrete and steel work in unique combination in prestressed concrete cylinder pipe. Here the pipe **anticipates** the pressures and loadings it will take in operation. How does it work? ■ Compression is built into the pipe by winding a precast concrete core with high tensile steel wire. The stressing operation is precisely controlled so that the built-in compression is ready to offset the variety of loadings the pipe will take under operating conditions. ■ The performance of this pipe is so accurately predictable that concrete and steel are used to greatest advantage. ■ Our customers have found that prestressed concrete cylinder pipe is economical for larger diameters, high pressures, or heavy loadings. ■ This may be the pipe for your next pipeline project. Let us talk it over with you.

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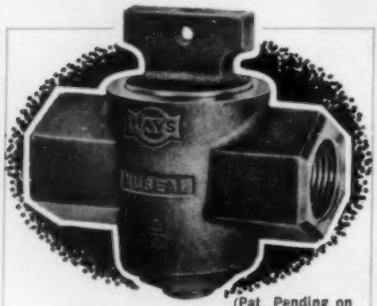

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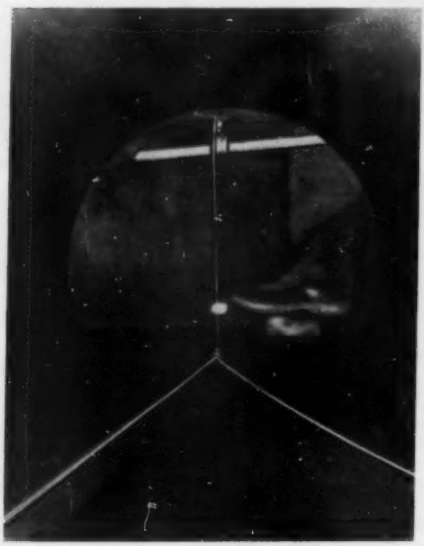
(Continued from page 50 P&R)

Herman A. Klenner, superintendent and general manager, Rahway (N.J.) water department, has been appointed by Governor Robert A. Meyner to the New Jersey State Water Policy and Supply Council. His appointment fills the vacancy created by the death of Thurlow C. Nelson during the hurricane last September (December P&R p. 46).

The inside story of a 24-in. sewer line, 8 ft underground, was photographed in color recently, using, we are happy to report, a remote-control camera. Not to provide realism for a detective or spy thriller, the pictures were taken to determine the condition of the coal-tar enamel lining on the inside of the concrete line after 4 years of carrying a combination of sanitary and storm wastes ranging from 0.5 to 2 mgd. That the lining was in excellent condition (see cut) was a source



(Continued on page 84 P&R)

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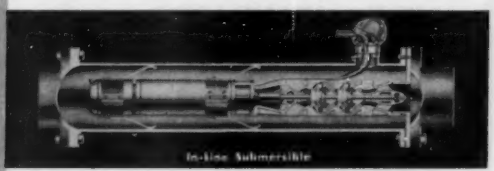

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Key: In the reference to the publication in which the abstracted article appears, 39:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, 39:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *BH—Bulletin of Hygiene (Great Britain); CA—Chemical Abstracts; Corr.—Corrosion; IM—Institute of Metals (Great Britain); NSA—Nuclear Science Abstracts; PHEA—Public Health Engineering Abstracts; SIW—Sewage and Industrial Wastes; WPA—Water Pollution Abstracts (Great Britain).*

POLLUTION CONTROL

Quality Chart of the Fulda From Mecklar to Hann. Munden. K. NOTHLICH & H. KNOPP. *Deut. Gewasserkundl. Mitt.* (Ger.), 3:30 ('59). A detailed account, with tables and graphs, is given of chem. and biologic examn's. of the river Fulda between Mecklar and Hann. Munden, in June 1956. The examn. was done in 4 sections, of which the first showed conditions above the mouth of the Eder, the second stretched from the mouth of the Eder to the town of Kassel, the third from Kassel to the dam at Spiekershausen, and the fourth from below the dam to the junction with the Werra. In the first stretch, self-purification of the already pold. water is interrupted at many places by discharges of sewage and industrial wastes. The Eder introduces water from an impounding reservoir which is only slightly pold. and improves the condition of the Fulda. At Kassel, sewage and industrial waste waters are discharged. Effluent from the sewage works of Kassel is discharged from the right bank, and the left of the river receives acidic waste waters carried by the Losse. In the final stretch to the junction with the Werra, self-purification proceeds, but biologically the river is still in poor condition. An investigation at a time when no excess water is being discharged from the Eder would be valuable.—*WPA*

Taking Samples in Polluted Running Water. *Bul. mens. inform. Assoc. franc. Et. Eaux* (Fr.), 8: No. 74 ('59). A procedure for taking samples of pold. rivers or streams for chem. and bacteriologic anals. is described in detail, and the manner in which the findings should be submitted to the appropriate authorities in France is presented. —*WPA*

Detergents in Water and Sewage. D. JUSTICE. *Soap Chem. Specialties*, 36:55, 174 ('60). This is the 5th annual report of research by the Am. Assn. Soap & Glycerine Producers on development of information related to effects of household detergents in sewage treatment and water supplies. Several projects are briefly reviewed.—*CA*

Experiments for Removing Anionic Syndets Discharged Into River Waters. M. CHAMBON & A. GIRAUD. *Bul. acad. natl. med.* (Paris), 144:631 ('60). A lab. study was made of the possibility of elimg. anionic syndets such as alkylarenesulfonates (which resist biol. disintegration) prior to the sewage discharge into river waters. The expts. were based on the oxidn. of the syndets by H_2O_2 in the presence of catalysts ($CuSO_4$, NH_4 metavanadate, $MnSO_4$, $Co(NO_3)_2$, Mohr's salt, $Fe_2(SO_4)_3$), and on their adsorption on various materials (bentonite, kieselguhr, alumina, talc, sand, pulverized coke and charcoal, and activated C). Details on the materials and procedures used are given, and the results obtained are tabulated and discussed. The disintegration of the anionic syndets by oxidn. was shown to be directly related to the amt. of H_2O_2 and the type of the catalyst used ($MnSO_4$ and Mohr's salt are most effective). Charcoal and activated C completely adsorbed the syndets, but the duration of their effectiveness was rather short. One fourth of the syndets was destroyed by bubbling O into a suspension of syndet-activated C–$CuSO_4$ at room temp.—*CA*

Chlorinated Insecticides in Surface Waters. A. A. ROSEN & F. M. MIDDLETON. *Anal. Chem.*, 31:1729 ('59). In the evaluation of the quality of surface waters, a general monitoring procedure that can detect a variety of common insecticides in concns. less than those toxic to aquatic life is required. This result is accomplished by combining the processes of carbon filter sampling, adsorption chromatography, and infra-

(Continued on page 64 P&R)

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(Continued from page 62 P&R)

red spectrophotometry. The above method has proved sufficiently sensitive to identify less than 10 ppb of 8 chlorinated insecticides in river water. A quantitative est. is also obtained. The method has been tested with aldrin, benzene hexachloride, chlordan, DDD, DDT, dieldrin, endrin, and methoxychlor.—*PHEA*

Permissible Concentrations of Synthetic Fatty Acids in Water Reservoirs. N. V. GRIN. *Trudy Khar'kov. Med. Inst.* (USSR), No. 46, 259 ('58). An examn. of the effects of sep. fractions of synthetic fatty acids (**I**) on the organoleptic properties of water, on the saprophytic microflora, and on the biochem. processes of self-purification of reservoir water is given. The threshold concn. of **I** in regard to odor increases with the increase of the size of the mols. of the **I** fraction. The BOD increases with an increase in the size of the mols. of the fraction up to C_{10}–C_{16}, and then decreases slightly. **I** show a stimulating effect on the development of the saprophytic microflora. Their development increases with an increase in the dosage of any **I** fraction, and decreases with the increase in the size of mols. in the fraction. A concn. >3–4 mg/l inhibits both the 1st and 2nd phases of nitrification; the intensity of the reaction depends on the size of the mols. in the fraction and the concn. of **I**. A limiting criterion in the detn. of the max. permissible concns. of **I** is their effect on the biochem. processes and the O balance of the water reservoir. According to this criterion, the limiting concn. for all **I** fractions can be considered as 0.1 mg/l.—*CA*

Synthetic Detergents in Well Water. J. DELUTY. *Pub. Health Repts.*, 75:75 ('60). Synthetic detergents have appeared in well waters in Suffolk County, N.Y., and on Rhode Island, in areas where there was no public water supply or sewerage system. The detergents arrive in the wells by leaching through the ground water, from septic tanks and absorption fields. Unlike soaps, synthetic detergents are not pptd. by Ca and Mg ions in the soil or the septic tanks and are also resistant to biologic action. The Dept. of Health, Rhode Island, investigating complaints of tastes, odors, and foaming of well waters, found that 56% of the samples received were coliform positive, and 89% were grossly pold., as measured by chem. methods. Of the samples, 73% were from wells located within 50 ft of a sewage disposal unit; and 94%, from wells within 100 ft of a sewage disposal unit. In 25 wells examnd., 6 were bacteriologically contamnd., but only 1 well was free from synthetic detergent. The presence of a high nitrate concn. in the well water suggests that oxidation of carbonaceous and nitrogenous pollutants from the septic tank effluent has taken place in the soil, but that the synthetic detergent molecule has resisted biologic oxidation. The Rhode Island Dept. of Health recommended that the min. size of lots in areas with no public water supply and sewerage systems should be 2 acres and that wells should be located more than 100 ft from any sewage disposal system.—*BH*

In-Plant Pollution Control in Practice. I. Petroleum Industry. S. O. BRADY. *Chem. Eng. Progr.*, 55:45 ('59). The following controls are described: (1) sepn. of drainage and sewer systems—cooling water and unpold. storm water also being sepd. from pold. water; (2) segregation of waste water streams and collection of spent caustic and spent acid solns. to obtain a neutral soln.; and (3) conservation and reuse of water, including recirculation of cooling water and use of air-cooled exchangers. Hydrofining, clay treatment, and elec. coalescing are among suggested process modifications. Recovery and utilization of caustics, acid, and oil, and local disposal of caustics and phenols, are discussed.—*CA*

Pollution of Magnitogorsk Water Reservoir by Industrial Waste Water. L. P. ALEKSANDROVA; A. V. KANYGINA; & P. I. POBEGAILO. *Ochistka Prom. Stochnykh Vod, Vsesoyuz. Nauch.-Issledovatel. Inst. Vodosnabzheniya, Kanalizatsii Gidrotekh. Sooruzhenii i Inzhener. Gidrogeol., Sbornik* (USSR), No. 2, 57 ('59). The water reservoir on the Ural river (190×10^6 cu m capacity) receives 10^6 cu m of sewage/24 hr, of which 13% is pold. wastes. The water passes 3–4 times per year through industrial plants. The amt. of pold. substances requiring biochem. purification exceeds significantly the reservoir self-purification capacity. If, in the near future, adequate sewage purification is not carried out, difficulties may arise in supplying Magnitogorsk metal plants with H_2O.—*CA*

(Continued on page 66 P&R)

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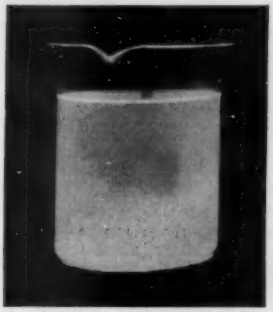
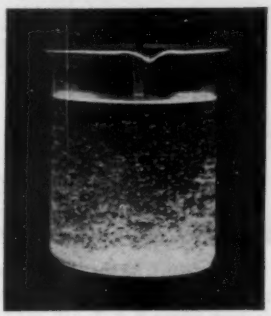


Untreated control sample of a turbid raw water.

Same water with 50 ppm alum added, photographed 7 seconds after ceasing agitation.



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Ground Water Pollution From Oil Well Residues. H. E. KLOTTER & R. NEUSSEL. *Gas- u. Wasserfach.* (Ger.), 100:1017 ('59). When ground and surface waters come into contact with oil well residues, they are readily pold. Polg. substances emphasized by the authors are phenol, creosol, and related petroleum derivatives. Demonstration was by chromatography.—*PHEA*

Modifications of Polluted Waters Resulting From Percolation in Soil. A. B. WHEATLAND & B. J. BORNE. *Centre belge etude et document. eaux, Bul. trimestr,* No. 49, 225 ('60). Tests conducted with a sewage effluent and water from the river Trent indicate that the percolation of these liquids through the soil removes NH_3 by cationic exchange. The removal of NH_3 depends on the nitrification of the NH_3 already adsorbed. At normal temps. during most of the year, most of the NH_3 is removed if an intermittent system of distribution (e.g., by 12-hr cycles) is employed. It is important not to distribute water contg. more NH_3 than the superficial bed can adsorb and to allow sufficient time between distributions for the penetration of atm. O and for the adsorbed NH_3 to be oxidized. In practice, the rate of percolation will be detd. both by the surface and by the perimeter of the area of aspersion, and the rate per unit of surface will vary inversely with the perimeter. Concns. of Cu, Ni, Cr, Mn, Zn, and Pb in the percolate were much lower than in the water distributed. The proportion of bacteria removed varied between 81% and 96.5% within the test area considered.—*CA*

Determination of the Dilution Rate of Sewage for the Sanitary Control of Water Reservoirs. M. A. RUFFEL. *Gigiena i Sanit.* (Moscow), 3:19 ('58). The mixing of water in an artificial water reservoir is achieved under quite different conditions to those in a natural stream. The author worked out a method of calcn. of the diln. of effluents in a reservoir—e.g., when the

(*Continued on page 68 P&R*)

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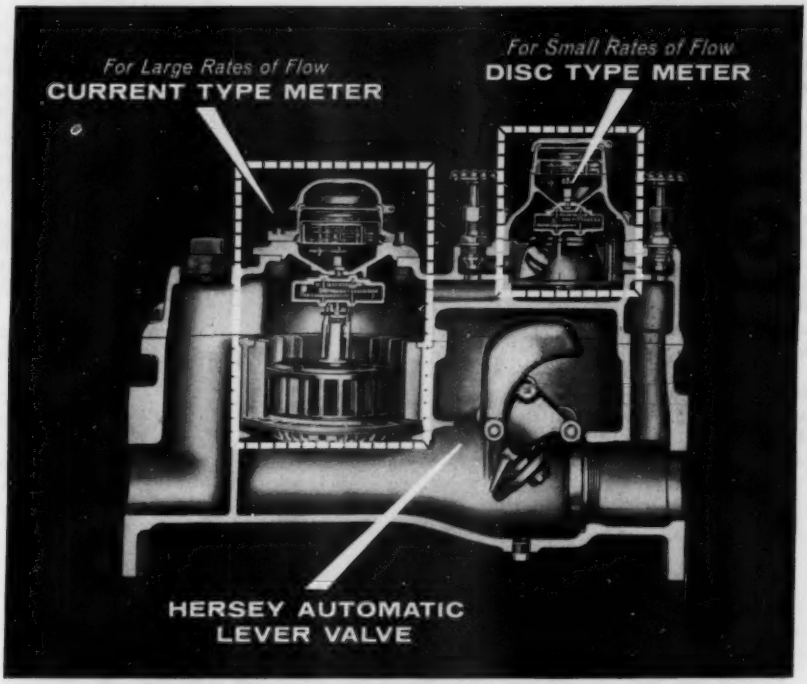

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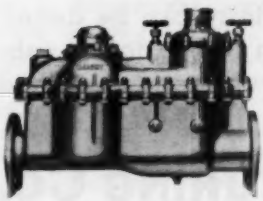

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(Continued from page 66 P&R)

sewage is discharged on shore or at a distance from the shore (at a definite depth). As the results obtained by the use of these formulas were close to the actual diln. rates detd. analytically, the proposed method may be successfully used for calculations.—*PHEA*

The Struggle Against the Pollution of the Waters in the Longwy Basin. E. Floquet. *Eau* (Fr.), 45:304 ('58). Problems involved in a stream basin, in which a large concn. of steel mills, coke furnaces, and related industries is located, are described. Such poln. controls as are effected are carried out with the cooperation of the Inter-Industry Pollution Com., the forest service, the bridges and highway service, and the rural san. engr.—*PHEA*

Electrical Charges of Colloidal Particles in Surface Waters and Use of Polarography in Coagulation Experiments. Z. Novak. *Literaturber. Wasser, Abwasser, Luft & Boden,* 7:17 ('58). Author describes expts. on use of an indirect polarographic method for detg. amt. of coagulant necessary with organically pold. surface waters. Surface waters in Czechoslovakia generally contain humus and protein matter as electronegative lyophilic colloids which foam on aeration and depress oxygen maximums to a greater or less extent. Mineral impurities contributed by rain or melting snow do not affect oxygen maxima; they are either neutral or electropositive. A certain alk. is necessary for complete removal of these colloids by coagulation. The polarographic method has proved satisfactory in quant. control of purity of surface waters.—*WPA*

Production of Drinking Water From Radioactivity Polluted Water. H. Roshard. *Schweiz. Bauztg.* (Switz.), 77:109 ('59). The causes of poln. by atom bomb tests or in war and the danger of the use of such drinking water for more than a limited time are pointed out. For the purification, especially of salt-rich drinking wa-

(Continued on page 70 P&R)

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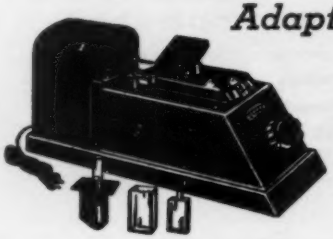

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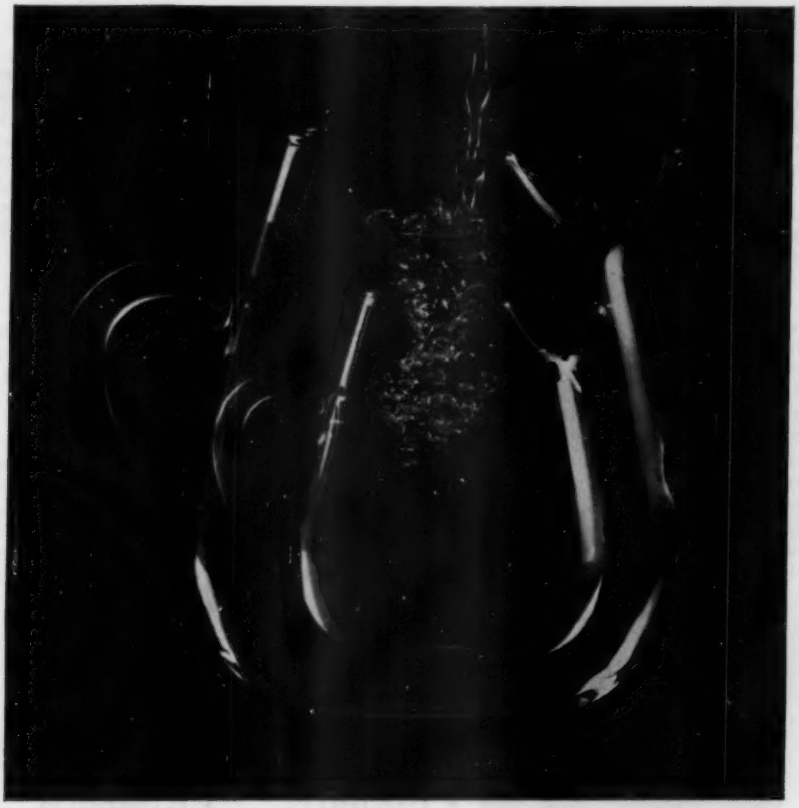

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(*Continued from page 68 P&R*)

ter (as it is mostly the case in Switzerland), equipment with ion exchangers is used. As thereby, however, the mineral constituents are also removed, a subsequent restitution of the necessary salts has to be made. A purification app. is described which combines one or several filtering processes with an ion-exchange process and subsequent salt addn. Expts. showed a reduction of the radioactivity of the water to less than 0.1% of the original value.—*PHEA*

Pollution of a Water Reservoir by Diphenylyl-Propane Sewage. L. N. GABRILEVSKAYA & M. N. RUBLEVA. *Vodosnabzhemie i Sanit. Tekh.* (USSR), 10:32 ('57). Investigations were carried out to det. the effects of discharging varnish and paint factories waste waters, containing diphenylyl-propane, phenol, and sulfuric acid, to a water storage reservoir. The toxic effect of diphenylyl-propane on the warm-blooded animals present was investigated by injecting white rats with 4 ml of washed waste waters in a 1:150 diln. daily over a period of 20 days. During the expt., the animals did not show changes in weight, behavior, blood composition, or microscopic structure of the internal organs. The effect of the waste waters on the organoleptic properties of the water, however, proved to be a good indicator of poln., and the sulfuric acid present in the waste waters reduced the pH value of the water.—*WPA*

AQUATIC ORGANISMS

The Influence of Temperature on Respiratory Metabolism During the Development of the Sea Trout. K. MARCKMANN. *Medd. Danm. Fisk.-o. Havundersog, Kbh.* (Copenhagen), 2: No. 21 ('58). The respiratory metabolism of the sea trout was studied during its development from a fertilized egg to a stage corresponding to about 800-day deg., at different const. temps. and also when exposed to sudden alterations in temp. at stages between 140 and 160-day deg. At stages of more than about 250-day deg.,

(*Continued on page 72 P&R*)

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(Continued from page 70 P&R)

the respiratory metabolism showed a min. around 6°C. Sudden alterations in temp. in the period 140–160-day deg. caused demonstrable changes in metabolism only if the alteration took place in the range 3–9°C, and after this shock treatment the metabolism immediately returned to the level characteristic of normal development at the initial temp. Under certain conditions, a permanent alteration in temp. caused a radical change in metabolism. For example, eggs at the 120-day deg. stage transferred 3–9°C adapted themselves completely to the metabolism characteristic of the 9°C control animals, but those at the 301-day deg. stage transferred 9–3°C subsequently showed a metabolism much lower than that of 3°C control animals.—*WPA*

Changes in Bottom Fauna Composition and a Fish Kill Resulting From Pulp Mill Wastes. J. C. SPINDLER & A. N. WHITNEY. *Proc. Montana Acad. Sci.*, 19:107 ('60). The discharge of untreated pulp mill wastes promotes a heavy slime growth of *Sphaerotilus* on the river bottom (for a distance of about 0.75 mi) which decreases the fish production of the stream; the toxicants (from the pulp wastes) are lethal to game fish during the high-water temp., low-flow period of the year for at least a 20-mi section of the river (Clark Fork).—*CA*

Cause of Mortality of a Midsummer Plant of Rainbow Trout in a Southern Wisconsin Lake, With Notes on Acclimation and Lethal Temperatures. C. W. THREINEN. *Prog. Fish. Cult.*, 20:27 ('58). When rainbow trout were stocked in the Lower Nashotah Lake in southeastern Wisconsin in August 1956, they immediately showed distress and died soon after, although the temp. of the surface water (74°F) was well below the temp. regarded as lethal for the species, and other lakes had been satisfactorily stocked at the same time. Investigations showed that the ill effects were due to heat shock caused by the sudden change in temp. between the holding and receiving waters. It was found that rainbow trout could not withstand a temp. shock of 20°F above the acclimatization temp. of 54°F, but could tolerate a temp. shock of 15°F from an acclimatization temp. of 51°F. When the acclimatization temp. was raised from 54° to 65°F during a 24-hr period, the trout could withstand water at a temp. of 74°F with only minor distress for a short period. Trout stocked in small lakes showed little signs of distress, while mortality occurred under similar conditions in larger lakes. Tests showed that in small lakes where the cool water of the thermocline was less than 15 ft deep, it could be reached by the trout, and stocking would be successful regardless of temp. shock. It was also found that trout can become acclimatized in time to sudden increases in depth (20 ft), but not to sudden sharp temp. changes. It is recommended that rainbow trout should not be stocked when the temp. of the receiving water is 20°F higher than that of the holding water, and the thermocline is more than 15 ft below the surface. Before they are stocked in water warmer than 70°F, they should be acclimatized through a 24-hr period to a temp. within 10°F of the receiving water. It would not be mechanically feasible to stock trout within the thermocline in lakes having thermoclines below 15 ft.—*WPA*

The Biogenetic Components in the Tsimlyansk Water Reservoir (1952–55). V. I. ROGOZHKIN. *Gidrokhim. Materialy* (USSR), 28:12 ('59). An increased cont. of these components was observed during the 1st year of reservoir operation. Esp. large concns. were present in places of former large cities and villages. The distribution of this material was very heterogenous; there was no regularity in either horizontal or vertical direction. The Tsimlyansk Reservoir waters are rich in dissolved nutritious salts and can be considered a eutrophic basin. The absence of stable and distinct stratification of biogenetic components is characteristic for the Tsimlyansk Reservoir. This is due to the strong mixing of water by winds; quiet weather without winds is rare in this region. —*CA*

The Use of Toxaphene as a Fish Poison. F. F. HOOPER & A. R. GRZENDA. *Trans. Am. Fish. Soc.*, 85:180 ('57). Lab. tests on the insecticide toxaphene indicate that this chem. is more toxic to fish in hard water than in soft water. An increase in temp. from 50°F to 70°F increased the toxicity to bluntnose minnows approx. threefold. The insecticide was found to be much more toxic to min-

(Continued on page 74 P&R)

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(*Continued from page 72 P&R*)

nows than to any of 4 aquatic invertebrates tested. The lab. results were confirmed by observations on 2 lakes in Michigan. Although many groups of invertebrates were killed by toxaphene treatment, they reappeared while the lake water was still toxic to fish. Water stored in the lab. became detoxified most rapidly when it was exposed to light, when the concn. of DO was high, and when the temp. was high. Hard water with an alkalinity of 212 ppm became detoxified more rapidly than soft water with an alkalinity of 6 ppm. The rate of detoxification was accelerated by water movements, which brought the toxicant into contact with the walls and bottom of the aquarium, and also by the addition of a substrate of glass marbles or gravel; sand and mud were less effective. When the substrate was sterilized with dilute formalin and carbolic acid, detoxification was inhibited, indicating that the reduction in toxicity is caused by microorganisms.—*WPA*

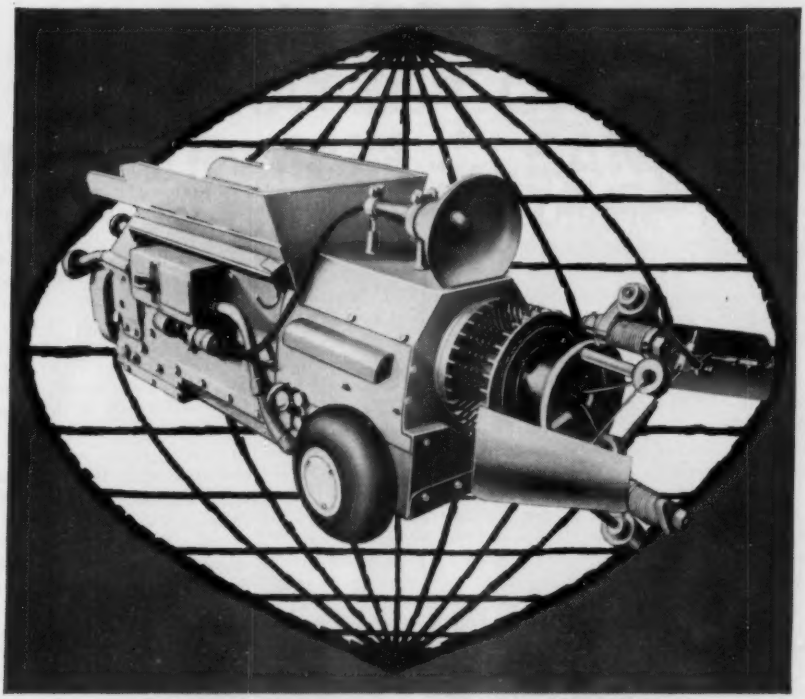
Estimation of the Productivity of Lakes and Ponds by the Use of C^{14}. Y. Saijo & T. Ichimura. *Dai-2-kai Nippon Isotope Kaigi Hobunshu, 2*:166 ('58). Under various conditions, the method with $Na_2C^{14}O_3$ gave satisfactory results in estg. the amt. of photosynthesis by pure culture of *Chlorella* and natural waters of lakes and ponds. Under sufficient light the results by this method agreed quite well with those by the DO method, whereas under weak light the former method gave somewhat smaller values, probably due to fixation of C by phytoplanktons to some extent even in the dark. Difference of the carbonate concn. in such cases as seen in natural waters of lakes and ponds in Japan had no significant influence on the amt. of photosynthesis by phytoplanktons.—*CA*

Shorewards Upslope of the Layer of Minimum Oxygen off Bombay: Its Influence on Marine Biology, Especially Fisheries. J. N. Carruthers et al. *Nature, Lond.*, 183:1084 ('59). During investigations in the Arabian sea off the Bombay coast in October–November 1958, an upwelling of the layer of min. oxygen was found, the layer having an avg oxygen cont. of 0.7 ml/l and occurring at an average depth of about 18 m some 18 naut. mi out from the coast. The salinity in this layer was about 36.0 per mile, the temp. about 24°C, and the phosphate cont. relatively high. The slope of the discontinuity layer was upwards towards the coast, and in a zone 7–10 naut. mi from the coast, the layer of min. oxygen almost reached the surface. The oxygen cont. there was very low from surface to bottom. Inshore of this zone, the coastal water contained higher amts. of oxygen. The 10-mi wide belt of water outside the 7-mi limit was regarded as the "upwelling and mixing" zone. The seasonal upwelling and the associated up-and-down movement of the layer of min. oxygen caused by the changing monsoons have various important effects on the local fisheries. During the north-east monsoon and the upward movement of the layer, demersal fish are forced to migrate shorewards to escape the low oxygen conditions. Pelagic fish remain outside the "upwelling and mixing" zone because of the low oxygen cont. of its water.—*WPA*

Aquatic Fungi in Water With High Waste Loads. W. B. Cooke & A. F. Bartsch. *Sew. & Ind. Wastes,* 31:1316 ('59). A number of relatively common aquatic fungi have been isolated from pools in areas of streams that receive domestic sewage and industrial wastes. Techniques of bait exposure are easily applied, but results of exposures made to date indicate that additional information gained in this way has little value in detg. the degree of poln. of a stream. In part, this may be due to having used too short an exposure time to obtain certain types of organisms; in part, it is due to the scouring of flash floods from unpredictable pptn. No aquatic fungi have been found with restricted distribution to pold. reaches of streams, and similarly no aquatic fungi have been found which are restricted to so-called clean water portions of streams. It is quite possible that more intensive study of the technique of using special baits, sampling periods, and altering other variables may yield a procedure of greater diagnostic value. When making surveys of any type of body of water for aquatic fungi, maintenance of a record of water quality data for sites at which aquatic fungi are found is recommended.—*PHEA*

Active Respiration of Fish in Relation to Ambient Concentrations of Oxygen and Carbon Dioxide. S. P. Basu. *J. Fish. Res. Bd. Can.,* 16:175 ('59). Speckled trout,

(*Continued on page 76 P&R*)



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(Continued from page 74 P&R)

brown bullhead, carp, and goldfish were acclimatized to various temps. and then made to maintain a steady rate of activity by mild electric stimulus. Their oxygen consumptions were measured in the presence of various concns. of oxygen and carbon dioxide at the temp. to which they had been acclimatized. It was found that the logarithm of the rate of oxygen consumption is linearly related to the concn. of carbon dioxide for each level of oxygen saturation, and this linear relation is characteristic of a given species at a given temp. The sensitivity to carbon dioxide changes with temp., being less at higher temps. The oxygen concn. det. the active level of oxygen consumption in the absence of carbon dioxide, but does not reflect the response to carbon dioxide except when the oxygen concn. approaches the lower lethal limit. The ability of the blood of a fish to take up oxygen in the presence of carbon dioxide shows no direct relation to the ability of the fish to transport oxygen from the external medium under activity.—*WPA*

A Simple Apparatus for Routine Zooplankton Counts. J. Bossanyi. *J. Cons. Int. Explor. Mer,* 24:452 ('59). An illustrated description is given of the design and operation of a simple app. for the routine counting of large numbers of easily identifiable zooplankton. It involves the flow of a controllable current of water carrying the preserved organisms through a suitably illuminated counting cell beneath the microscope objective.—*WPA*

Effects of Organisms on Pollution. D. F. Westlake. *Proc. Linn. Soc.,* 170:171 ('59). In badly polluted waters, the pop. of *Chironomus* larvae present are capable of lowering the O_2 concn. in the river by more than 1.0 ppm/mi at 15°C, while dense plant pop. result in great diurnal changes in the O_2 cont. of the water.—*PHEA*

Control of Growth of Algae With DMU [3-(*p*-chlorophenyl)-1:1-dimethylurea]. G. P. Fitzgerald. *J. Appl. Chem.,* 8:235 ('58). Quant. tests were made with 22 ssp. of algae to investigate the value of DMU as an algicide in fresh waters. DMU concn. of 0.5–1 ppm inhibited algal growth, while −5 times this concn. did not damage higher plants; fish were not harmed. DMU is recommended for control of algae after reduction of excess pop. by other means.—*PHEA*

Poisoning of Aquatic Fauna by Waste Water Pollution. K. Wuhrmann & H. Woker. *Vehr. Internat. Ver. Limnol.* (Ger.), 13:557 ('58). Influences of various types of pollutants on aquatic animal life are described. Reaction times of various types of fish are given for common pollutants on the basis of lab. experiments. Various ecologic factors affecting the aquatic environment are compared as to direct and indirect effects. The effect of chlorination on various organisms present in an aquatic environment is given on the basis of increase or decrease with time in a meter square area.—*PHEA*

Hydrobiology of the Vilaine River in the Channel Passing Through Rennes. F. Lagadec. *Bul. soc. sci. Bretagne* (Fr.), 33: 135 ('58). The chem. compn. of the water and the species of algae present are considered in detail. As it passes downstream through Rennes, the cont. of the water in salts and the alky. increase, while the DO diminishes. There are pos. correlations between the SiO_2 cont. and the nos. of diatoms present at different locations and also at different times of the year.—*CA*

Biological Assessment of River Pollution. R. W. Butcher. *Proc. Linn. Soc.,* 170:159 ('59). *J. Sci. Food & Agric.,* 10:104 ('59). With gross org. poln., the flora of the river consists of "sewage fungus" (chiefly *Sphaerotilus natans*) and the fauna of tubificid worms and *Chironomus* larvae. As the org. matter decomposes (with increasing distance from the source of poln.) *Asellus* replaces *Chironomus,* then molluscs appear and finally caddis fly larvae and fresh water shrimps. The algae *Nitzschia palea* and *Gomphonema parvulum* and *Stigeoclonium tenue* develop as the *Sphaerotilus* disappears and finally *Cocconeis placentula, Ulvella,* and *Chamaesiphon* become the dominant algae.—*PHEA*

Survival, and Protection Against Chlorination, of Human Enteric Pathogens in Free-Living Nematodes Isolated From Water Supplies. S. L. Chang et al. *Am. J. Trop. Med. & Hyg.,* 9:136 ('60). Free-living nematodes have been found with some

(Continued on page 78 P&R)

CALGON KEEPS FLOW RATES CONSTANT AFTER MAIN CLEANING

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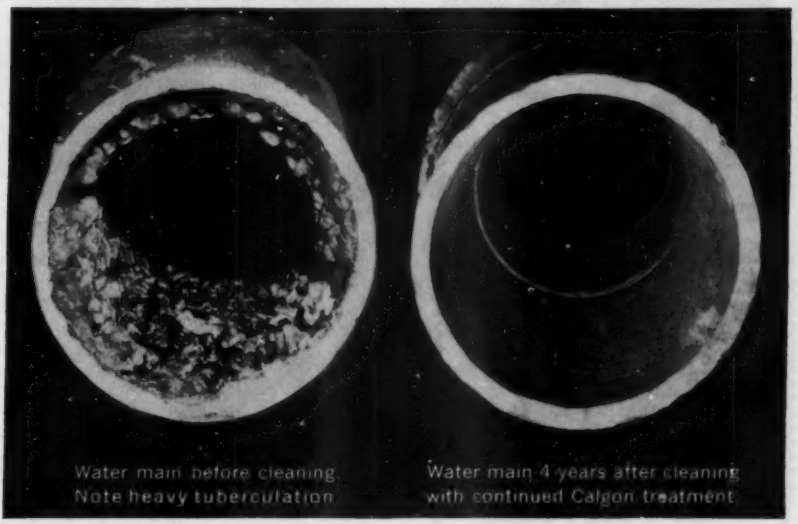

Water main before cleaning. Note heavy tuberculation

Water main 4 years after cleaning with continued Calgon treatment

Part of the Portland, Maine, Water District System supplies Sebago Lake water to Gorham Village. An 11,000-foot, 8-inch main was the main feed between a booster station and a standpipe at the far end. This main had not been cleaned for 20 years, and it was found that the flow coefficient "C" had dropped to between 50 and 56 due to massive tuberculation.

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(*Continued from page 76 P&R*)

frequency in some city water supplies in the United States and also in trickling filters of munic. sewage treatment plants. The authors had found that some of these nematodes fed readily in the lab. on several types of coliform organisms, and some preliminary expts. had indicated that salmonellae and shigellae could survive in the worm gut for up to 4 days. Later, two nematodes, *Diplogaster nudicapitatus* and *Cheilobus quadrilabiatus*, were cultured in the laboratory, and adults and larvae were fed in different batches on *Salmonella typhi, Salm. paratyphi, Salm. typhi-murium, Shigella sonnei, Sh. dysenteriae* II and samples of Coxsackie and ECHO enteroviruses. It was found that the nematodes readily ingested plate cultures of the bacteria and fluid suspensions of the viruses. About 5–6% of the ingested typhoid and Sonne bacilli and about 12–16% of the paratyphoid bacilli and Coxsackie A9 virus survived for 24 hr in the gut of the worms, but after 48 hr the survivals were reduced to 0.1 and 1.0%, respectively. There was no evidence of excretion by the forms of living pathogens. The nematodes were found to be highly resistant to the destructive action of free chlorine in the water and were unaffected by 120-min exposure to 2.5–3.0 ppm chlorine. Even with an initial chlorine cont. as high as 95–100 ppm, 50–60% of the nematodes survived a 5-min contact, and 10–20% survived a 15-min contact. The ingested pathogens were so protected in the gut of the carrier nematodes that they had complete survival when 90% of the worms were immobilized by the free chlorine. Although the majority of the ingested pathogens tend to disappear after 1–2 days, a significant proportion may remain viable if the worms are carried from their normal habitat to water supplies within 24 hr, and they will survive routine chlorination as practiced in the field. It is concluded, therefore, that nematodes of the Rhabiditidae family of sewage treatment origin may be potential carriers of human enteric bacteria and viruses.—*BH*

CORROSION

Chromized Steel—A New Low Cost, Heat, Wear, or Corrosion Resistant Material. R. P. Seelig. *SAE J.*, 66:42 ('58). By means of the Chromalloy process, ordi-

(*Continued on page 80 P&R*)

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(Continued from page 78 P&R)

nary iron and steel can be made to resist rusting like stainless steel, or resist wear and abrasion like tungsten carbide and be protected against oxidation similar to high alloy materials. Chromalloy process, or Chromallizing, is a patented method of diffusing Cr and other elements into the surface of metal. As Cr diffuses into base metal it combines with elements therein to form an alloy case which is an integral part of base metal, but with properties of the new alloy. Unlike superficial coatings, the case will not peel, spall, chip, or flake off. Stainless steels, Ni or Co base alloys, W, Mo, and other metals can be Chromallized to provide protection from oxidation and erosion at very high temps. up to 3,000 F.—*Corr.*

The Use of Sodium Nitrite in Corrosion Protection. S. P. NAGY. *Gep* (Hungarian), 11:265 ('59). $NaNO_2$ can be used to inhibit metal corrosion in water and in neutral or weakly alkaline soln. Its effectiveness depends on concn., Cl cont., pH, and temp.—*IM*

The Resistance of Commercial-Purity Aluminium to Water at High Temperatures. H. J. GESKE. *Aluminium*, 36:199 ('60). The author surveys the present rather contradictory state of knowledge, as revealed in the literature, on the behavior of Al towards water at temp. up to 300°C as used as a coolant in nuclear reactors, and puts forward some possible explanations of these anomalies. An Al alloy with 1% Ni and 0.5% Fe shows promising results from the corrosion point of view.—*IM*

Tests on Underwater Paints, Particularly for Drinking Water Tanks. G. SILLE & O. DAMM. *Technik* (Berlin), 14:39 ('59). The tests showed that a chlorinated polyvinyl chloride gives much better protection against corrosion than a bitumen. When a chlorinated polyvinyl chloride is used for drinking water tanks, the usual plasticizer, tricresyl phosphate, must be replaced by dibutyl phthalate and chlorinated diphenyl to prevent contamn. of the water with traces of phenols.—*Corr.*

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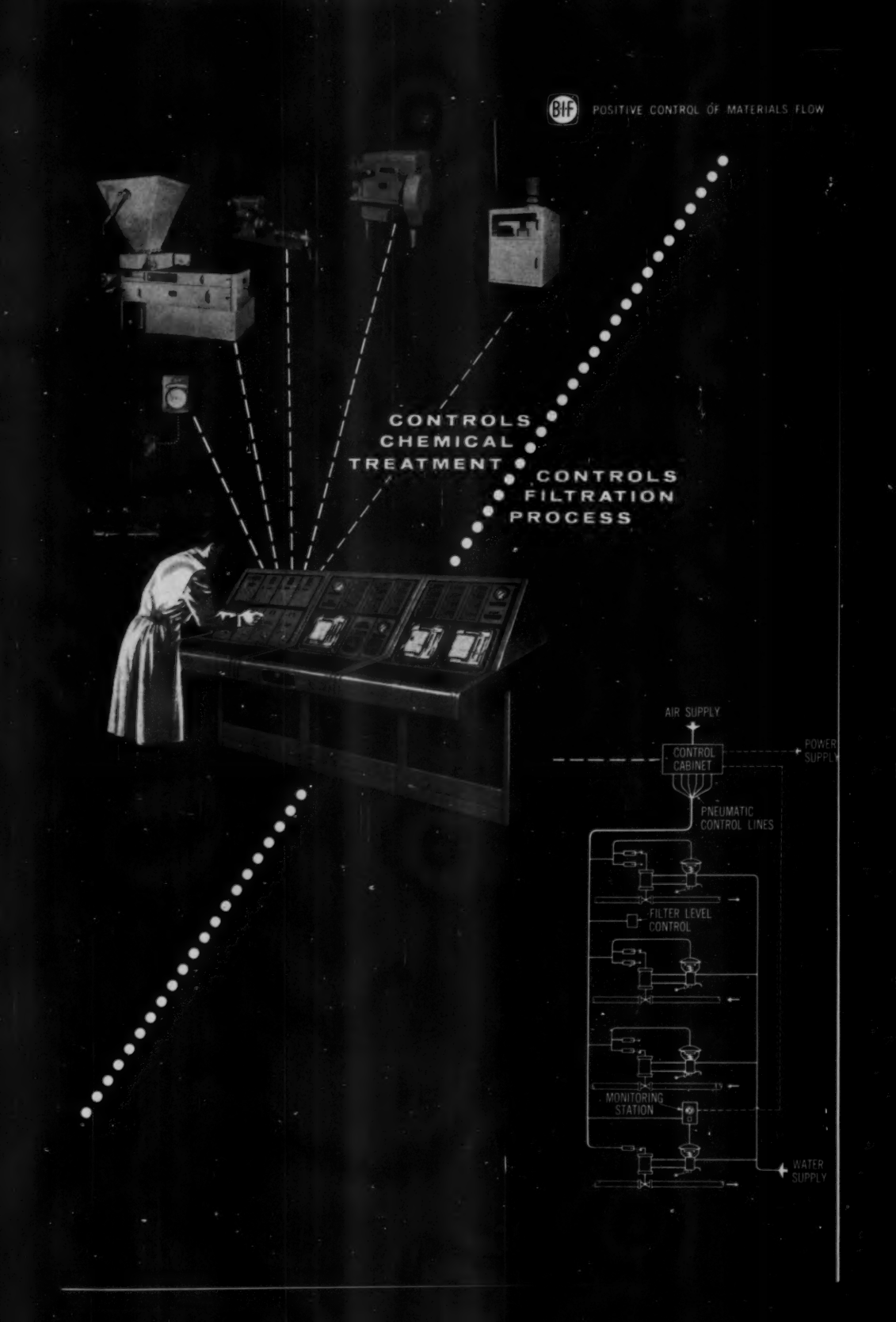

(Continued from page 52 P&R)

of satisfaction to the producer and owner. That the camera, a waterproof 16-mm one, mounted on steel runners and carrying its own strobelight source, survived the ordeal was a source of interest. But that the pictures, 360-deg shots triggered automatically at 2-ft intervals, were clear—well, that is, distinct, yes, distinct—was amazing. Of course, your water lines mightn't be as colorful, but perhaps worth a look anyway.

Producers of the show were the Jersey Testing Laboratories, Inc., Newark, N.J.; sponsors, the Jersey City Sewerage Authority and the Koppers Co., Inc. Talk about Candid Camera!

A scale-type disease, known as *Matsucoccus resinosae,* has infested the red pine trees in the Wanaque (N.J.) watershed to such an extent that the North Jersey District Water Supply Commission has made arrangements to have 160,000 trees cut down prior to October 1962. The damaged trees represent 25 per cent of the evergreens in the 5,700-acre watershed area. Foresters estimate that the financial loss will "run into the tens of thousands of dollars," which will be partially offset by the sale of mature timber and wood chips. Replanting of another pine species is scheduled to be completed by 1964.

The disease, which originates in the Orient, was first discovered in the US in 1946, but only recently was the insect responsible for the damage identified. Outbreaks were first reported at Bridgeport, Conn., in 1948 and at Yonkers, N.Y., and on Long Island in the mid-1950's. It is suspected that the disease was originally carried by shrubs imported to the US from the Orient for planting at the World's Fair.

Harry D. Clark, chief engineer, Kankakee (Ill.) Water Co., died May 18, 1961, at the age of 54. He had been with the utility since 1923, when he started work as an office clerk and meter reader. In 1930, he became a laboratory technician, was named assistant plant superintendent in 1945, and became plant superintendent in 1957.

A charter member of the Illinois Water Plant Operators Assn., he was named as the state's "operator of the year" in 1957. He was a member of AWWA since 1958.

August V. Graf, formerly chief chemical engineer of the St. Louis Water Division, died on May 14, 1961, at the age of 79. Born in St. Louis in 1882, he received his A.B. in chemistry from Washington University in 1904, after which he served the university as an instructor. From 1906 to 1911, he was a chemist for the St. Joe Lead Co., following which he joined the St. Louis Water Div. as chief chemical engineer, the position he held until his retirement in 1960.

A member of AWWA since 1914, he received the Fuller Award in 1940 and was a Life Member of the Association. He was also a member of APHA, AICE, and NEWWA.

Ralph E. Hall, pioneer in the field of water treatment chemistry and director emeritus of Hagan Chemicals & Controls, Inc., died May 2, at his home in Rehoboth Beach, Del. at the age of 76. Born in Charlestown, Ohio, he received both his bachelor and mas-

(Continued on page 86 P&R)

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(Continued from page 84 P&R)

ter of science degrees from Ohio Wesleyan University in 1907 and 1908 respectively. He received his master of arts degree from Ohio State University in 1911 and his Ph.D. in physical chemistry from the University of Chicago in 1916. In 1925 he founded Hall Laboratories, industrial water consulting firm and a division of Hagan, and served as its director until his retirement in 1950. He was an active member of Hagan's board of directors from 1927 until his resignation in 1956, when he was named director emeritus. His experiments with the problem of scale formation in steam boilers in the late 1920's led to his discovery of sodium hexametaphosphate as an effective agent for the chemical treatment of boiler water.

Prior to founding Hall Laboratories, he had served as a physical chemist with the US Bureau of Mines, the Koppers Co., and with the Geophysical Laboratory at the Carnegie Institution of Washington. He was director of physical-chemical research for Firestone Tire and Rubber Co. and an assistant professor of chemistry at Iowa State University.

Michael J. Harper, vice-president, Meter & Valve Div., Rockwell Mfg. Co., died on Mar. 19, 1961, in Brooklyn, N.Y., at the age of 69. After attending Brooklyn Polytechnic Institute, he joined Rockwell as a salesman in 1922 and served for 29 years as New York district sales manager. He became eastern regional manager in 1951 and was elected vice-president in 1953.

A member of AWWA since 1949, he was also a member of NEWWA and active in the American Gas Assn.

Orrin L. Isham, formerly utilities superintendent at Oxnard, Calif., died on May 16, 1961, at the age of 61. Born in Ventura, Calif., he was first employed by the city of Oxnard in 1921, as inspector for the water department. He became assistant superintendent in 1929 and superintendent in 1930. At the time of his retirement, last January, he was the city's senior employee in years of service. He was a member of AWWA since 1938.

Frederick O. Runyon, senior partner of Runyon & Carey, consultants, Newark, N. J., died on May 6, 1961 at the age of 86. A member of AWWA since 1936, he was former president of the New Jersey State Board of Professional Engineers and Surveyors and a Fellow of AIEE.

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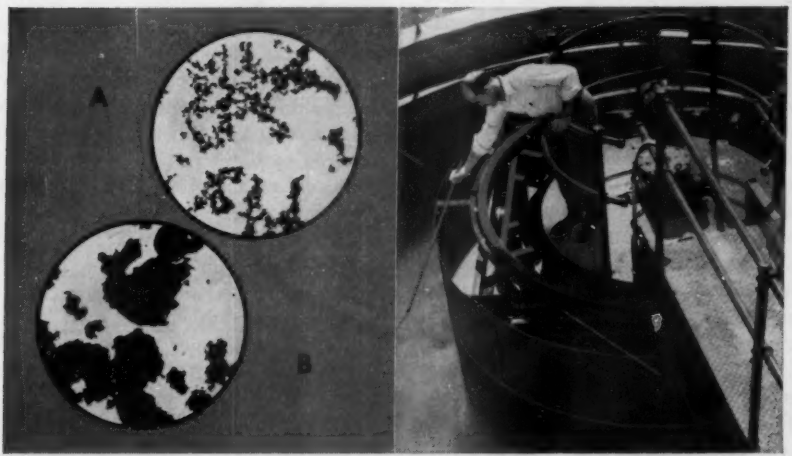

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To the Editor:

I would like to add one suggestion to James P. Dovel's letter, published in the May issue (P&R page 66).

It is that we build our water and other health facilities only in those countries that have a system of taxes on income and property comparable to our own and that still cannot afford a water supply. I see no reason for give-away programs that impose taxes and give the Americans the privilege only of paying taxes for others. For some 20 years the "Point Four" or similar programs have constructed health centers and water and sewerage facilities in other parts of the world for anyone who will accept them. We might try to force new plants on some 5,000 communities in the US who do not have them or who need new plants.

I can furnish Mr. Dovel with the names of towns in other parts of the world where we paid for the plant, where the local mayor collects the monthly bill from the consumer, keeps the money, and the program pays the cost of plant operation. Visiting these plants with their program engineer to try to talk the mayor into paying operating costs, we were given a standard answer, "You built the plant without my approval (true), and you should therefore pay for the cost of operation." Since this is the mayor's privilege and prerogative, I am inclined to agree with him. Income and property are not taxed in the entire country, so the water plant is a source of income to assure his own salary and other expenses.

Most peoples of the world have complete disrespect for those who "gush" at them with money and for those that try to induce them to change their culture or living conditions. There are a lot of Georgia towns that, I'll wager, would like to have a water plant.

JOE A. BOYER

Atlanta, Ga.; May 25, 1961

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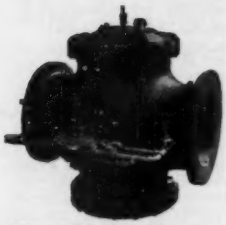

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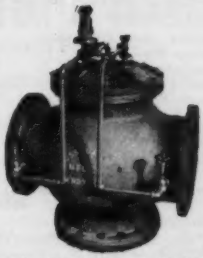

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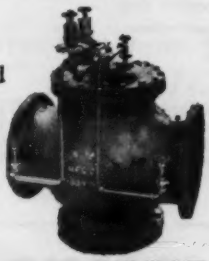

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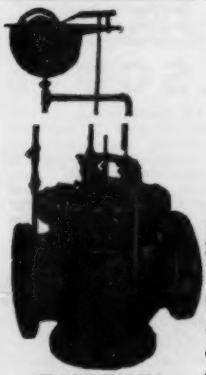

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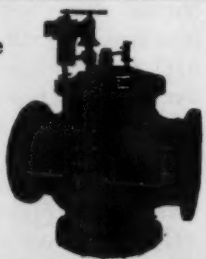

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Alum (Sulfate of Alumina):
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General Chemical Div., Allied Chemical Corp.

Ammonia, Anhydrous:
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Ammoniators:
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Fischer & Porter Co.
Wallace & Tiernan Co., Inc.

Ammonium Silicofluoride:
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Associations, Trade:
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Cast Iron Pipe Research Assn.
Steel Plate Fabricators Assn.

Brass Goods:
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Hays Mfg. Co.
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Brine-Making Equipment:
International Salt Co., Inc.

Calcium Hypochlorite:
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Calculators Hydraulic:
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Carbon Dioxide Generators:
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Cement Mortar Lining:
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Halliburton Co.
Southern Pipe Div. of U.S. Industries

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B-I-F Industries, Inc.—Proportioneers
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Permutit Co.
Simplex Valve & Meter Co.
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Chemists and Engineers:
(See Professional Services)

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B-I-F Industries, Inc.—Proportioneers
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Wallace & Tiernan Inc.

Chlorine Comparators:
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Klett Mfg. Co.
Wallace & Tiernan Inc.

Chlorine, Liquid:
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Wallace & Tiernan Inc.

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Dresser Mfg. Div.
Mueller Co.
A. P. Smith Mfg. Co.
Trinity Valley Iron & Steel Co.

Clamps, Bell Joint:
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Clamps, Pipe Repair:
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Dresser Mfg. Div.
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1955-1961

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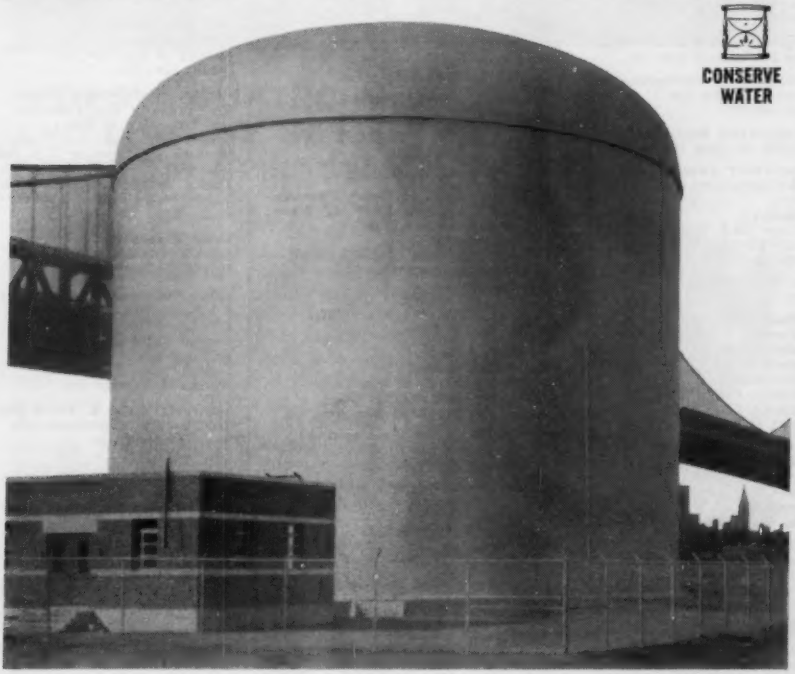

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Nalco Chemical Co.
Philadelphia Quartz Co.

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United States Pipe & Foundry Co.
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Permutit Co.
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Filtration Equipment Corp.
General Filter Co.
Golden-Anderson Valve Specialty Co.
Hungerford & Terry, Inc.
Infilco Inc.
F. B. Leopold Co.
Permutit Co.
Simplex Valve & Meter Co.
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Permutit Co.
Stuart Corp.

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Tennessee Corp.

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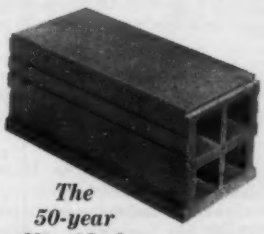

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Fischer & Porter Co.
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Neptune Meter Co.
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Trinity Valley Iron & Steel Co.
United States Pipe & Foundry Co.
R. D. Wood Co.

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Lock Joint Pipe Co.
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Pipe Locators; see Locators, Pipe

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Sleeves: see Clamps

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The Clariflow combines flocculation, good fluid mechanics and clarification in a relatively small tank. Mixing, flocculation, stilling and sedimentation are independently operated and controlled. The positive control of flocculation and clarification enables the operator to readily select the most economical method of operation when handling changeable water conditions.

Short circuiting tendencies are eliminated by means of exclusive multiple, tangential diffusers which simultaneously and equally distribute the flow. Balanced multiple surface weir troughs make efficient use of short detention periods and insure clarified overflows.

The Clariflow is applicable wherever there is a municipal or industrial need for water or waste treatment. It can be used in all operations including combined intimate chemical homogenizing, flocculation and clarification in rectangular, square or circular basins. The Clariflow gives excellent results in the treatment of municipal and industrial water for—softening—turbidity removal—color removal—algae removal. Industrially it is universally used in—oil separation and emulsion breaking plants—blast furnace flue dust thickening—paper stock reclamation.

Write for bulletin 6W46.

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B-I-F Industries, Inc.—Omega
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Wheeler, C. H., Mfg. Co.

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Golden-Anderson Valve Specialty Co.
Ross Valve Mfg. Co., Inc.

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B-I-F Industries, Inc.—Builders
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DeZurik Corp.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Pelton Div., Baldwin-Lima-Hamilton
Rockwell Mfg. Co.
R. D. Wood Co.

Valves, Detector Check:
Hersey-Sparling Meter Co.

Valves, Electrically Operated:
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B-I-F Industries, Inc.—Builders
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Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Rockwell Mfg. Co.
A. P. Smith Mfg. Co.

Valves, Float:
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Golden-Anderson Valve Specialty Co.
Rockwell Mfg. Co.
Ross Valve Mfg. Co., Inc.

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Dresser Mfg. Div.
Kennedy Valve Mfg. Co.
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R. D. Wood Co.

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B-I-F Industries, Inc.—Builders
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Darling Valve & Mfg. Co.
DeZurik Corp.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
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M & H Valve & Fittings Co.
Mueller Co.
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A. P. Smith Mfg. Co.
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Kennedy Valve Mfg. Co.
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Pelton Div., Baldwin-Lima-Hamilton
Rockwell Mfg. Co.
A. P. Smith Mfg. Co.
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DeZurik Corp.
Golden-Anderson Valve Specialty Co.
Mueller Co.
Rockwell Mfg. Co.
Ross Valve Mfg. Co.

Valves, Swing Check:
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Golden-Anderson Valve Specialty Co.
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Mueller Co.
Rockwell Mfg. Co.
A. P. Smith Mfg. Co.
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Koppers Co., Inc.
Plastics & Coal Chemicals Div., Allied Chemical Corp.

Water Softening Plants; see Softeners

Water Supply Contractors:
Layne & Bowler, Inc.

Water Testing Apparatus:
LaMotte Chem. Products Co.
Wallace & Tiernan Inc.

Water Treatment Plants:
American Well Works
Chain Belt Co.
Chicago Bridge & Iron Co.
Dorr-Oliver Inc.
General Filter Co.
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Pittsburgh-Des Moines Steel Co.
Walker Process Equipment, Inc.
Wallace & Tiernan Inc.

Well Drilling Contractors:
Layne & Bowler, Inc.

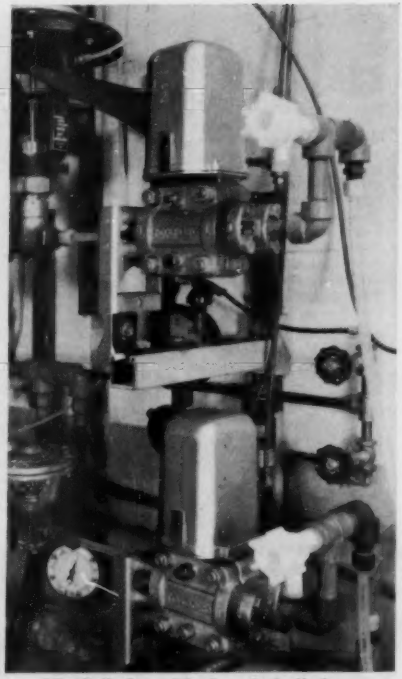
Well Reconditioning and Formation Testing:
Halliburton Co.
Layne & Bowler, Inc.

Wrenches, Ratchet:
Dresser Mfg. Div.

Zeolite: see Ion Exchange Materials

A complete Buyers' Guide to all water works products and services offered by AWWA Associate Members appears in the 1959 AWWA Directory.

Foxboro M/40 Ratio Controllers regulate exact amount of liquid alum being added to raw water.



8% AL_2O_3 flows right through the Foxboro Integral Orifice d/p Cell. There are no pressure taps – nothing to bind or plug up.

Problem of metering liquid alum solved with the Foxboro Integral Orifice d/p Cell* transmitter

Unique system helps Salem and Beverly Water Board save $2000 per year in water treatment costs

The Salem and Beverly (Massachusetts) Water Supply Board had a problem. They wanted the economy of liquid alum as a coagulant for water treatment. However, conventional metering devices tended to "coat" or bind when exposed to alum-and-water solution. Continued, accurate measurement was impossible.

Installation of Foxboro Integral Orifice d/p Cells proved the perfect answer. Since this unique transmitter can meter flows as tiny as .003 gpm, it permits ratioing alum syrup direct to raw water – without the problems of dilution. What's more, its wide rangeability permits using the same transmitter for both summer and winter alum feed requirements.

In over 2 years of operation, Salem and Beverly report, "there has been no evidence of plugging of our Integral Orifice d/p Cells – measurement has been stable."

Providing stable measurement of liquid alum is just one of the ways Foxboro control can improve your operating efficiency. Ask your Foxboro Field Engineer for complete details – or write for Bulletin 1-15. The Foxboro Company, 167 Norfolk St., Foxboro, Mass.

*Trade-Mark

FOXBORO

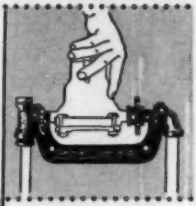
REG. U. S. PAT. OFF.

a few plain words about...

WATER METERS!

METER YOKES

The Ford Yoke dates back to 1911. Its outstanding success resulted in a wide variety of meter holding devices called yokes. But the Ford yoke as now made offers advantages not obtainable in any other type of meter setting. Millions are in use.

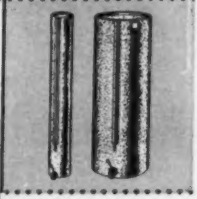


LIFTER WORM LOCK

The original Ford Worm Lock was introduced almost forty years ago. Because of its simplicity, safety and powerful screw-jack action it is now widely used. The Lifter feature, a recent improvement, provides automatic attachment of the key on unlocking.

CALIBRATED TESTING TANKS

Before Ford Calibrated Testing Tanks were put on the market about 35 years ago, such meters as were tested were checked against gravimetric scales, which were complicated and inconvenient. Thousands of Ford Tanks are in service, in sizes from one to 1000 gallons.



METER VALVE

The Meter Valve is a close-coupled combination of an inverted key valve and a meter connection. It saves material, pipe joints and space in the meter setting. Ford Meter Valves bear the trademark name of Ringstyle Valves.

THE KORNERHORN

In a vertical basement pipe, against the wall or in a corner, the Kornerhorn makes a most satisfactory meter setting. Installation is fast and economical as pipe threading is eliminated. Send for detailed information.

Meters can *earn* real money. In most water utilities they measure and determine *all* the income.

It is good business to accord meters the treatment they deserve as valuable equipment and as sources of revenue. Such enlightened treatment includes settings which provide protection, easy availability for reading, and trouble-free meter changes for proper maintenance.

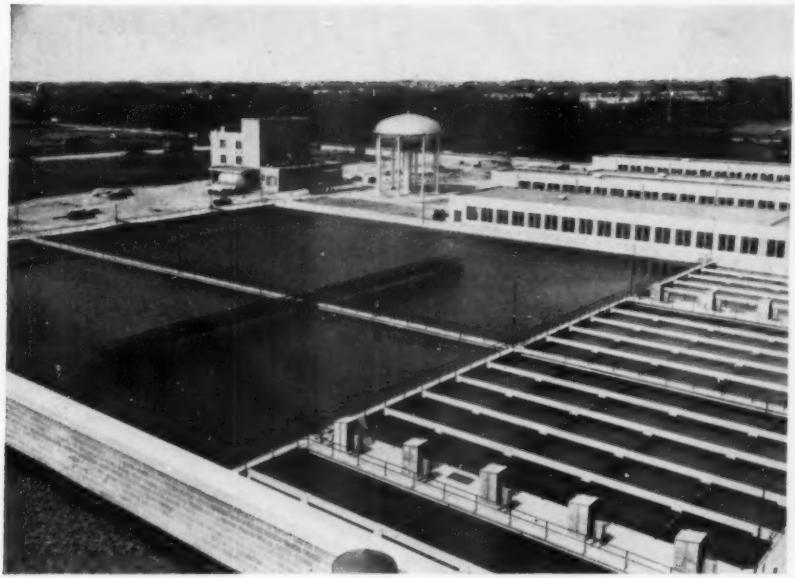
For 60 years our company has served thousands of water utilities in providing better water meter settings. Submit *your* problems to Ford.

THE FORD METER BOX COMPANY, INC.

FOR BETTER WATER SERVICES

WABASH, INDIANA

FORD



Philadelphia's push-button treatment plant uses

DORR-OLIVER EQUIPMENT

With the completion of the new Torresdale plant, Philadelphia not only fulfills its dream of a completely modern water treatment system, but also possesses a show place of advanced equipment and design ideas.

An extensive system of automatic and semi-automatic controls makes this literally a "push-button" plant. Contributing to its high efficiency are important items of Dorr-Oliver equipment. Four Dorrco Flocculators are installed, each with five rows of paddles 14′ dia. x 174′6″ long spaced on 19′7″ centers. There are also four Dorr Cross-Flow Squarex Clarifiers, each 174′6″ square x 19′6″ s.w.d. Maximum design capacity of the plant, one-half of which is shown above, is 423 MGD. Dorr-Oliver Incorporated, Stamford, Connecticut.

Consulting Engineers: Morris Knowles Inc., Pittsburgh, Pa. *Contractors:* McCloskey and Company, Philadelphia, Pa.

DORR-OLIVER

WORLD-WIDE RESEARCH • ENGINEERING • EQUIPMENT

"Specified and used over 600,000 feet of Transite Water Pipe."

A. R. Todd, Consulting Engineer,
A. R. Todd and Associates,
Wheeling, W. Va.

"Transite® Pipe gives our clients distinct advantage in economy," says Mr. Todd. "It is quick and easy to install, and once in service the economies continue. That's because Transite remains unaffected by external or internal corrosion, assures a tight and flexible installation for the life of the system, protects the quality of the water it carries, and minimizes maintenance and operation costs. We have found these features to be very important in an area known for highly corrosive soils and rocky terrain.

"We have specified and used over 600,000 feet of Transite Water Pipe in the past ten years on dozens of projects. We are convinced that Transite is the best value for the money. Our clients have been well-satisfied, too."

Why not let Transite help *you* reduce community water system costs? Let us send you our "Facts and Data for Engineers" book. Write Johns-Manville, Box 14, JA-7, N. Y. 16, N. Y. In Canada: Port Credit, Ontario. Offices throughout the world. Cable address: Johnmanvil.

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